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**SCIENCE AND TECHNOLOGY:
CHALLENGES, PROSPECTS
AND INNOVATIONS**



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MODERNIZATION OF UKRAINIAN PHARMACY HIGHER EDUCATION TO THE INNOVATIONS OF THE 21ST CENTURY

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Abstract: The purpose of the paper is to emphasize the importance of continuous adaptation in pharmaceutical education to meet the changing needs of the industry, and to prepare students for future challenges. The key developments of pharmacy including personalized medicine, integration of artificial intelligences, gene therapy and digital health solutions, etc. are summarized. The need for pharmaceutical education to adapt to area's innovations, proposing curriculum changes, that include interdisciplinary approaches, advanced technological training, and industry collaboration are highlighted. Also strategies for motivating university staff to adopt new educational paradigms were proposed.

Keywords: higher education, pharmaceutical education, pharmaceutical industry, innovations, motivation.

There have been several significant changes in the world pharmaceutical area over the past five years due to: COVID-19 pandemic impact; rapid progress in computing power and data analytics; increased access to large datasets enabling more

sophisticated research and personalized medicine approaches; advancements in fields like genomics, immunology, and neuroscience; environmental concerns and economic pressures due to Russian invasion into Ukraine, etc. All these factors lead to increased focus on infectious disease research and preparedness, and expanded use of remote pharmacy services and home delivery; to greater use of electronic prescribing and digital health records; increased implementation of artificial intelligence and machine learning in drug discovery and development; progress in pharmacogenomics for tailoring treatments to individual genetic profiles, increased market presence of biosimilars (similar versions of biologic drugs); and growth awareness of environmental impact, etc. These factors have collectively driven the pharmaceutical industry to adapt, innovate, and evolve in response to new challenges and opportunities. So, among all the above-mentioned categories of novelties, **the main trends** in the pharmaceutical industry are:

Personalized medicine: Increased focus on treatments tailored to individual patients based on genetic profiles and biomarkers [1].

AI and machine learning: Growing use of artificial intelligence in drug discovery, clinical trials, and patient care optimization [2].

Gene and cell therapies: Continued development of innovative treatments like CAR-T cell therapy and CRISPR gene editing [3].

Digital health integration: Greater adoption of digital tools, wearables, and apps for patient monitoring and drug adherence [4].

Biosimilars: Expanding market for biosimilar drugs as patents on major biologics expire [5].

Immunotherapies: Ongoing advancements in cancer immunotherapy and expansion to other disease areas [6].

RNA-based therapies: Increased interest in mRNA and siRNA technologies, building on the results of COVID-19 vaccines [7].

Outsourcing and partnerships: More collaborations between pharma companies, biotech startups, and academic institutions [8].

Sustainability: Increasing emphasis on environmentally friendly practices in

drug manufacturing and packaging [9].

Preventive medicine: Greater emphasis on “health span” extension therapies [10].

3D bioprinting: Advancements in bioprinting of tissues and organs for drug testing and eventually transplantation [11].

In silico clinical trials: Development of more sophisticated trials to reduce the need for human subjects in early-stage testing [12].

Drug pricing pressures: Growing focus on value-based pricing models and efforts to address high drug costs [13].

To better prepare students to be up-to-dated in a more dynamic, technologically advanced, and patient-centric pharmaceutical landscape, universities should consider to introduce **the following changes** into their **educative** process:

Interdisciplinary curriculum: Integrate courses combining biology, chemistry, data science, AI and computer science. Offer programs that blend pharmaceutical sciences with business and ethics.

Advanced technology training: Incorporate bioinformatics and computational biology into core curricula. Provide hands-on experience with AI and machine learning tools for drug discovery.

Personalized medicine focus: Develop courses on genomics, proteomics, and pharmacogenomics. Teach principles of biomarker discovery and targeted therapies.

Digital health and data analytics: Offer classes on digital health technologies, wearables, and health apps, and related regulatory considerations. Train students in big data analytics and its applications in healthcare.

Gene and cell therapy education: Expand courses on advanced biotechnologies like CRISPR and CAR-T. Provide laboratory experience in gene editing and cell culture techniques.

Industry collaboration: Establish more internship programs with pharmaceutical companies to give students hands-on experience with industry challenges. Bring in industry experts as guest lecturers or adjunct professors.

Soft skills development: Emphasize communication, teamwork, and project

management skills. Provide training in regulatory affairs and ethical considerations.

Entrepreneurship and innovation: Offer courses on drug development processes and commercialization, innovation management, and technology transfer. Encourage participation in biotech startups.

Virtual and augmented reality training: Implement virtual reality technologies for laboratory simulations and manufacturing process training.

Sustainability awareness: Incorporate green chemistry principles into pharmaceutical courses. Teach sustainable practices in drug manufacturing and packaging.

Regulatory affairs and ethics: Strengthen courses on evolving regulatory landscapes, especially concerning new technologies and personalized medicines.

Continuing education programs: Develop flexible, up-to-date courses for professionals to stay current with rapidly evolving trends.

Global health perspectives: Incorporate courses on global health challenges, rare diseases, and strategies for addressing unmet medical needs in diverse populations.

The U.S. [14] tend to lead in integrating emerging technologies and research into education, while Germany [15] and Switzerland [16] have strong industry collaborations. Japan's [17] focus on internationalization reflects its aim to play a larger role in the global pharmaceutical industry. Despite the growing awareness of AI technology among pharmacy professionals in the Middle East and North Africa region [18], there are still significant gaps in its understanding and application in pharmaceutical practice. Ukrainian pharmaceutical education can benefit from adopting elements from leading countries, particularly in the areas of industry collaboration, integration of data science and AI, and emphasis on personalized medicine and biopharmaceuticals.

Its known, that implementation of new trends in the industry is driven by a diverse ecosystem of stakeholders [19]. At the core are pharmaceutical companies, biotech firms and academic institutions that lead research and development. They work with government agencies, healthcare providers and regulatory agencies to

ensure the safety, effectiveness and availability of new medicines and treatments. The research organizations help with clinical trials, and supply chain companies ensure efficient distribution. Environmental groups push for sustainability, and patients themselves play a critical role in employing new treatments and technologies. Insurance companies influence drug prices and availability, while investors and venture capitalists fund promising businesses. International organizations and policy makers shape the global health landscape and regulatory environment.

But the initial responsibility for the **implementation** of these innovations **in the pharmaceutical university** should be borne by:

University administration: Allocating resources for curriculum updates and new programs. Establishing partnerships with industry and research institutions.

Accreditation members: Updating standards to reflect the evolving needs of the pharmaceutical industry. Encouraging innovation in educational approaches.

Government agencies: Providing funding for educational programs and research initiatives. Facilitating academia-industry collaborations through policy measures.

Industry partners: Providing input on skill requirements and emerging technologies. Offering internships and collaborative research opportunities.

Faculty members: Updating course content to reflect current industry trends. Engaging in continuous learning to stay current with technological advancements.

Students: Actively engaging in interdisciplinary learning and seeking out relevant experiences. Providing feedback on curriculum relevance and effectiveness.

The exact timeline for implementation may vary depending on factors such as institutional readiness, funding availability, and regulatory considerations. Continuous evaluation and adjustment will be necessary to ensure that educational programs remain aligned with industry needs.

Motivating university staff to embrace significant changes is indeed challenging, especially during war in Ukraine now. Nevertheless, here are some strategies that could help:

Communicate the vision clearly: Explain how these changes benefit students,

the university, and society. Show how staying current enhances the university's reputation and competitiveness.

Supply resources and support: Ensure staff have the tools and resources needed to implement changes. Offer ongoing support and troubleshooting.

Increase autonomy and flexibility: Allow faculty more freedom in course design and teaching methods. Offer flexible working arrangements where possible.

Create a culture of innovation: Encourage experimentation and tolerate failures as learning experiences. Showcase success stories and best practices.

Provide professional development opportunities: Offer training programs to help staff acquire new skills. Create opportunities for attending conferences or workshops in emerging fields.

Collaborative environment: Foster interdepartmental collaborations. Create mentorship programs pairing experienced staff with newcomers.

Gradual implementation: Phase changes in slowly to prevent overwhelming staff. Start with pilot programs and expand based on feedback.

Recognition and non-monetary rewards: Implement an awards system for innovation in teaching or research. Offer opportunities for leadership roles in new initiatives.

Streamline processes: Look for ways to reduce administrative burden. Invest in technology that can automate routine tasks.

Career advancement opportunities: Tie participation in new initiatives to promotion criteria. Create new roles or titles that reflect expertise in emerging areas

Emphasize personal growth: Frame the changes as opportunities for personal and professional development. Highlight how new skills can enhance career prospects.

Involve staff in decision-making: Seek input from faculty and staff when planning changes. Create task forces or committees to drive implementation.

Align with personal values: Appeal to educators' desire to provide the best possible education. Emphasize the positive impact on students' future careers.

Create a sense of community: Organize events or retreats focused on the

change initiative. Foster a sense of shared purpose and teamwork.

Conclusions: The pharmaceutical industry of the world is undergoing rapid and significant transformations driven by technological innovation, global healthcare challenges and changing patient expectations. These shifts require a parallel evolution in pharmacy education to ensure that future professionals have the skills and knowledge necessary to thrive in this dynamic environment. Proposed changes to Ukrainian university curricula, focusing on interdisciplinary learning, advanced technology and hands-on industry experience represent an important step in bridging the gap between academic training and industry needs.

Implementing these changes will require collaborative efforts by various stakeholders, including university administration, faculty, industry partners, and regulatory authorities. Although the process can be challenging, especially in the context of resource constraints and resistance to change, the potential benefits for students, the industry, and ultimately patient care are substantial. By fostering a culture of innovation, providing ongoing support and development opportunities, and emphasizing the long-term value of these adaptations, universities can motivate staff to embrace these necessary changes. As the pharmaceutical industry continues to evolve, educational institutions must remain flexible by continually evaluating and updating their programs to ensure they remain at the forefront of pharmaceutical science and practice. Ultimately, this transformation in pharmaceutical education will play a critical role in shaping the future of Ukrainian healthcare, driving innovation in drug development, and improving patient outcomes worldwide. The ability to adapt and integrate these new trends will be key to preparing the next generation of pharmaceutical professionals to address the complex health care challenges of the 21st century.

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