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Neurobiology as an Interdisciplinary Science in the System of Natural Sciences

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Abstract: *The presence of neurobiology as an interdisciplinary science in the system of natural sciences has become the basis for the development of the academic discipline "Fundamentals of Modern Neurobiology" as a component of the natural science training of future psychologists in higher education institutions. The main aim of the article is to structure the above-mentioned discipline to deepen and systematize the natural science knowledge previously mastered by psychology students to modern ideas about the physiological mechanisms of mental activity and human behavior, the causes of occurrence and the neural mechanisms of the main psychopathologies. To this end, one has achieved a number of partial results: a) the analysis of modern neurobiological sources has made it possible to determine the main areas of neurobiology as an interdisciplinary science in the system of the natural disciplines; b) one has justified the expediency of using interdisciplinary links when structuring the course on fundamentals of modern neurobiology; c) one has selected the three most promising areas of neurobiological research relevant to structuring the course on fundamentals of modern neurobiology. It has allowed one to design an integrative academic discipline "Fundamentals of modern neurobiology", which, combining three interdependent and interconnected modules, namely: "Neurobiological essence of human connection with the environment", "Cognitive neurobiology and modern ideas about the higher nervous activity of a person", "neurobiological changes and mechanisms of dysfunctions of the nervous system, higher nervous activity and sensory systems ", - will contribute to the effective implementation of the transformation of the content of natural science training of future psychologists, taking into account current trends in the present and the current state of development of neurobiological sciences.*

Keywords: *interdisciplinary connections, future psychologists, natural science knowledge, neural mechanisms, interconnected modules, neurobiological nature, cognitive neurobiology.*

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Introduction

Integration processes occurring in the scientific environment, as a rule, lead to the emergence of new sciences, and in education - to the emergence of new disciplines.

In the system of natural sciences, these processes are quite active, so it can be considered a leader in science. For example, integration processes led to the emergence of biophysics, biochemistry, bioinformatics, bioengineering, biomechanics, biomedicine, neurobiology and other sciences.

The presence of neurobiology as an interdisciplinary science in the system of natural sciences became the basis for the development of the discipline "Fundamentals of Modern Neurobiology" as a component of natural science training of future psychologists in higher education.

We consider it appropriate to emphasize that the development of any discipline involves its preliminary design, namely: outlining the subject, goals and objectives, interdisciplinary links, determining the expected learning outcomes and competencies they will form, approximate thematic planning.

The scientific training of future psychologists is interpreted as a basis for their mastery of professionally oriented knowledge and skills, taking into account some ideas of Neporozhnya (2018) that the natural sciences: a) "create theories that determine the characteristics of human ideas about the world and oneself, form its awareness of the scientific picture of the world and are decisive in its creation; b) they are leading in changing the paradigm of scientific thinking; c) influence the creation of basic models of cognition; d) form the basis of applied sciences; e) it is the most important element of human spiritual culture, one of the essential indicators of the level of civilization… ". Therefore, one can outline the subject of study and the purpose of the proposed discipline “Fundamentals of Modern Neurobiology”. Also, the article substantiates the expediency of interdisciplinary links and areas of assessing the acquired competences.

Different aspects of the problem under study are covered in the works of many scholars (Nerubasska & Maksymchuk, 2020; Melnyk et al., 2019; Sheremet, Leniv, Loboda, & Maksymchuk, 2019; Gerasymova et al., 2019).

The main objectives of the designed training course are: a) to expand the understanding of psychology students about the value of natural science training in substantiating professional actions, developing creative potential and increasing the level of competitiveness in the labor market; b) teach

future psychologists to analyze, synthesize, generalize natural science knowledge and notice the prospects for their practical application; c) to form students-psychologists ideas about the natural scientific methodology of the analysis of mental phenomena and human behavior, about the possibilities and place of physiological research methods in psychological practice; d) to form in future psychologists the ability to interpret age-related characteristics of mental activity, human behavior and to recognize the characteristics of the main psychopathologies, using the results of modern neurobiological research.

Literature review

Lately, humanities and borderline sciences are paying more and more attention to neurobiological foundations of learning and cognitive processes accompanying it. Modern research has shown that neurobiological methods can be used to observe and adjust the hierarchy of links (molecular – cellular – systemic (brain areas) during the acquisition, memorization and production of knowledge.) Besides, neurobiological cognitive processes are almost identical to pedagogical processes of learning and acquisition of competences. In this regard, researchers claim that "there are significant opportunities for the integration of modern knowledge about the biology of learning with educational strategies and curriculum development" (Friedlander et al., 2011).

The specially developed and realized strategies of cognitive neurobiology have already contain the concepts of implementing three main practical aspects (sensory perception, sensorimotor coordination and microphysical realization) in pedagogy and psychology (Churchland, 1986). Being somewhat reductionist, this approach has nevertheless shown considerable effectiveness in practice. According to Eichenbaum (1997), the discovery of declarative memory different from its other forms is a major recent achievement in cognitive science. The main questions about the nature of declarative memory are considered in the context of its basic brain mechanisms. Numerous studies show that declarative memory is mediated by a specific brain system, including areas of the cerebral cortex and hippocampus which significantly contribute to memory processing (Eichenbaum 1997). Declarative memory, which is easily diagnosed and observed, is a marker of more complex processes, such as flexibility, systematicity, spontaneity of expression, depth.

Kelly et al. (2006) have analyzed a number of studies on the neurobiology of aging and summarized the main areas of gerontological

studies on neurobiological changes during "normal aging". They are as follows: a) the mechanisms of hippocampal plasticity; b) calcium dyshomeostasis and synaptic communication (testing "the calcium hypothesis" in aging); c) the loss of synaptic connections; c) neuropathological changes along with Alzheimer's disease (Kelly et al., 2006). As noted by Eclarinal & Ajilore (2017), neuroimaging allows one to determine structural and biochemical markers of age-related pathologies (the decrease in gray matter' the increase in white matter hyperintensity and neurochemical changes). The researchers prove that oxidation processes and mitochondrial dysfunction of brain cells are one of the main causes of bipolar disorder in elderly patients.

Regarding the neurophysiology-environment relationship, Kempermann (2019) confirms that the environment enriched with stimuli based on the available genotype can change the neurogenesis of the hippocampus in adults. This change affects the plasticity of the brain manifested externally in the expansion of acts and patterns of behaviour, as well as in the increase of individual experience. Neurobiological studies on human behaviour in society enable one to establish the dependence of deviant behaviour (aggression) on changes in metabolism, the specifics of the subregions of the prefrontal cortex and the intensity of transport of serotonin and dopamine. These aspects endogenously determine the cognitive-behavioural specificity of the individual and can depend on the environment. Due to reflexive perception, the latter may increase or decrease neurophysiological factors (Cupaioli et al., 2021).

Another important aspect is the justification of interdisciplinary links as the most important factor in optimizing the educational process. According to Burzhinskaya (2007), Konyok (2013), Neporozhnya (2018), one of the important reserves for improving the educational process in higher education is the establishment and application of interdisciplinary links in the formation of curricula, study programs, choice of information and educational material, etc.

Konyok (2013) considers interdisciplinary communication as "the most important factor in optimizing the learning process, increasing its effectiveness, reducing the overload of lecturers and students". The researcher asserts that this is due to "the modern level of development of science, characterized by a pronounced integration of social, natural and technical knowledge".

Neporozhnya (2018) agrees with Konyok (2013) who notes that "by introducing interdisciplinary topics in programs and defining interdisciplinary links between individual topics, where there is a need and

opportunity, it is possible to achieve harmonization of the content of natural subjects".

According to Burzhinskaya (2007), one of the main functions of interdisciplinary relations among the disciplines of natural science training is the consistent reflection in their content of the objective relationships that operate in nature. According to the scientist, interdisciplinary natural-scientific connections are manifested in the systematization of knowledge obtained by students and form the basis for the formation of a scientific worldview and comprehensive development of personality.

Following the views on the expediency of the active introduction of interdisciplinary connections to increase the motivation of students in the study of non-core fundamental disciplines, Burzhinskaya (2007) notes that their use in higher education institutions causes certain difficulties, which, according to the scientist, are associated with the traditional isolation of academic subjects and the search for connections between highly specialized courses.

Among the most common difficulties faced by lecturers of higher education institutions in the process of organizing the educational process on the basis of interdisciplinary links, Burzhinskaya (2007) singles out the difficulties associated with the organization of cognitive activity of students, namely, with the formation of desire and ability to establish links between knowledge from different disciplines and cognitive interest in worldviews of science.

Methods

The main research methods include induction (generalization of modern neurobiological achievements), surveying of actors in the educational process (students), as well as the method of designing (an academic discipline).

The design of the thematic plan of the discipline "Fundamentals of Modern Neurobiology" was carried out taking into account the fact that psychology students already have a certain level of natural science knowledge and skills provided for by the State Standard (Ministry of Education and Science of Ukraine, 2019) and the program in biology for general educational institutions, the formation of which was facilitated by educational material, is highlighted in the developed by us and the textbook "Biology for the 8th grade" recommended by the Ministry of Education and Science of Ukraine, the textbook for the 8th grade of general educational institutions (Strashko, Horyana, & Bilyk, 2016) and the educational-

methodical manual "Biology: Workbook" (Strashko, Voytsekhivskyy, Bilyk, & Ihnatenko, 2016).

We consider it appropriate to note that when forming the content of this integrative discipline, we took into account the results of a survey of psychology students and practicing psychologists, the results of a theoretical analysis of the content of school textbooks and workbooks, and research of domestic and foreign scientists on the theory of modern education. In particular, we relied on scientific views of Andrushchenko, & Lutay (2008) on the expediency of interpreting the educational function of education as one that involves teaching future generations of students the knowledge and skills that are the property of society and their coverage in development, and educational as such that is aimed at the socialization of man, ie the formation of a system of spiritual values, which simultaneously combines the interests of the individual and the interests of society; principles of competence orientation of higher education, which, according to Sysoeva (2015), make "the expansion of academic and professional recognition and mobility, the correlation of diplomas and qualifications of specialists in our country and the European educational and research space", in accordance with which it is necessary to separate "Target and competence" spaces ", covering" international landmarks and contexts, when creating educational resources to distribute competences into two groups: "general and professional" that "must ensure the fulfillment of the requirements for academic and professional training; the theory of didactic integrology by Kozlovska (2011), according to which "the application of the basic laws of didactic integration and their consequences makes it possible to create didactic systems based on basic fundamental knowledge". Kozlovska (2011) believes that the advantage of such systems is that they together are constant (based on fundamental knowledge and didactic laws) and variable (respond quickly to changing social requirements), while the main course becomes the integrator that groups knowledge in accordance with the requirements of a particular profession.

When designing the content of the above-mentioned academic discipline, we took into account the scientific works of Okoń (1998) and Zagvyazinsky (2008) on the formation of the content of education. Okoń (1998) argues that when shaping the content of education, it is necessary to take into account the criteria associated with a person who is involved in the educational process and develops, and society is changing. Zagvyazinsky (2008) agrees with this point of view and proposes a generalized structure with which, according to the scientist, it is advisable to form the content of all academic disciplines, namely: the introduction, or the basis of science,

reveals the modern natural science and social picture of the world, that is, a set of fundamental concepts, laws , theories, basic facts and types of problems that science solves the main areas of application of theoretical knowledge; methodological approaches that ensure the conscious mastery of knowledge by a person and the development of his thinking, in particular, information about the history of knowledge; knowledge necessary to ensure all or many spheres of human life and activity: unsolved, but important scientific and social problems; generalizing principles and provisions, form in the consciousness of the individual an understanding of the unity and development of the world.

Results

Thus, given the above, in the process of teaching the discipline "Fundamentals of Modern Neurobiology" provides for the formation of general and special (professional, subject) competencies that require the presence of scientific knowledge, skills and abilities.

We believe that having a certain level of scientific training in the subjects studied in the school course of biology, students of psychology are able to independently or in terms of individual-consultative cooperation with the lecturer (according to student needs) to deepen it in accordance with modern advances in neurobiology.

In our opinion, this approach to designing an integrative course "Fundamentals of Modern Neurobiology" allows a lecturer of higher education to spend more time studying more complex topics of the course and promotes the formation of students-psychologists creative activity, perseverance, desire for scientific self-development, self-education and self-improvement and skills to independently search for the necessary scientific information, to understand and realize its subject area, to operate the natural-scientific conceptual and categorical apparatus, to analytically-critically process, analyze and generalize natural-scientific information from various sources and to formulate reasoned conclusions. So, given that in topic 7 "The relationship of the human body with the environment. Nervous system ", developed by us textbook" Biology for 8th grade "highlights the main aspects: the general structure and functions of the human nervous system; excitation and inhibition processes; impulse transmission in the nervous system; reflex activity of the human nervous system; structure and functions of the spinal cord, brain stem and cerebellum, diencephalon and terminal brain (the textbook for the 8th grade of general educational institutions (Strashko, Horyana, & Bilyk, 2016); in

topic 8 "The relationship of the human body with the environment. Sensory systems ", contains general characteristics of visual, auditory, chemoreceptor sensory systems and tactile sensitivity (Strashko, Horyana, & Bilyk, 2016); topic 9 "Higher nervous activity" reveals the basics of human behavior (congenital and acquired), features of signaling systems; sensation and perception; memory; emotions; physiological mechanisms and sleep hygiene (Strashko, Horyana, & Bilyk, 2016), and in the textbook "Biology: Workbook. Test tasks. Laboratory tests. Research tutorial", our proposed plans contain tasks for laboratory research and research workshops on these topics (Strashko, Voytsekhivskyy, Bilyk, & Ihnatenko, 2016). We were able to logically and rationally distribute the hours (credits) between the modules and topics of the developed discipline

Table 1. Thematic planning of the integrative discipline "Fundamentals of modern neurobiology"

There are 3 ECTS credits (90 hours)					
Module names	Total credits / hours	Distribution of hours provided for discipline training			
		In-class learning			Independent work of students
		Total classroom hours	Lectures	Seminar-practical classes	
Module I. Neurobiological essence of human connection with the external environment.	1/30	8	4	4	22
Module II. Cognitive neurobiology and modern ideas about higher human nervous activity.	1/30	12	6	6	18

Module III. Neurobiological aspect of age-related changes and mechanisms of disorders of the nervous system, higher nervous activity and sensory systems.	1/30	14	6	8	16
Hours in general	3/90	34	16	18	56

Systematized by the authors

Our preliminary theoretical design of the discipline "Fundamentals of Modern Neurobiology" allows us to characterize its content by modules and topics.

Thus, taking into account the above, the educational discipline "Fundamentals of modern neurobiology" developed by us has integrated three modules: "Neurobiological essence of human connection with the external environment", "Cognitive neurobiology and modern ideas about human higher nervous activity", "Neurobiological aspect of age-related changes and mechanisms of disorders functions of the nervous system, higher nervous activity and sensory systems "(Table 1), - the topics of which, according to the traditional system for the implementation of natural-scientific training of future psychologists in higher education institutions, are covered in several separate educational systems "," Physiology of higher nervous activity and sensory systems ", " Age physiology "," Fundamentals of medical knowledge ", " Valeology ", etc., - focused on the mono-aspect of teaching, during which the subject of study is interpreted from the standpoint of one biological characteristic , e.g., highlights either only the morphological features of the subject of study, or only its genetic aspects, or only its physiological features and etc., while the modules of the academic discipline developed by us are designed to ensure the end-to-end implementation of these tasks and the formation of a holistic system of professionally oriented neurobiological knowledge in students (and not a body of knowledge, as it happens according to the traditional system of natural-scientific training of future psychologists in institutions of higher education) which, of course, will contribute to the formation of the natural science competence of future psychologists, will become the basis for their professional training in higher education institutions, will allow the high-quality performance of future professional duties and thereby ensure the high competitiveness of the future psychologist in the labor market.

The use of interdisciplinary links and interdisciplinary integration of different branches of biology (morphology, physiology, genetics, ecology, etc.), chemistry, physics, valeology and medicine in the development of the

discipline "Fundamentals of Modern Neurobiology" gives grounds to consider it as an integrative discipline of the system natural-scientific training of future psychologists, which ensures the formation of their holistic natural-scientific competence.

Discussion

The analysis of relevant scientific sources proves that the module on the neurobiological essence of human connection with the external environment" is expedient to study. At the same time, the environment is considered in a broad sense, namely, as a natural and cultural environment. Regarding the latter, it essential to consider reasonable views of Doane, Sladek & Adam (2018) on the links between biology, new demographic models and cultural neurobiology. The basic idea is that there are constant transactions "between cultural processes and central and peripheral aspects of neurobiology over a number of time frames" (Doane, Sladek, & Adam, 2018). One can observe adaptive processes emerging in the human population surrounded by a certain cultural environment. These processes can be determined using biomarkers (allostatic load, activity of the autonomic nervous system, the specifics of hypothalamic-pituitary function).

Analyzing the current areas of neurobiological research, one can justify the need to single out the module on the neurobiological aspect of age-related changes and mechanisms of disorders in the nervous system, higher nervous system and sensory systems. Indeed, researchers have shown a link between individual mental and biological models which predict predisposition to exogenous mental disorders, including depression. The neurobiological basis of such disorders is closely related to social (depletion) and phenotypic aspects. In the laboratory, one can determine the degree of neuroplasticity, neurotransmitter changes. Psychological methods make it possible to identify the degree of stress, nervous tension. The article proves that all the above-mentioned mechanisms are "interconnected and interact bilaterally", and "psychological factors have a direct impact on neurodevelopment, causing a biological predisposition to depression, while biological factors can also lead to psychological pathology" (Dean, & Keshavan, 2017).

One should also distinguish the module on the neurobiological aspect of age-related changes and mechanisms of disorders in the nervous system, higher nervous system and sensory systems, given numerous neurophysiological studies on the frontoparietal and subcortical brain networks and cognitive disorders in traumatized patients and geriatric patients. The main empirical evidence is the role of neuroimaging these

areas. Modern neuroimaging methods allow one to assess not only the structural integrity of components of the central nervous system (CNS) but also its vascular, functional and molecular characteristics. These advances in neuroimaging help one understand the early and subtle age-related CNS disorders in more detail (Rosso, Nadkarni, & Rosano, 2020).

Sullivan's (2015) position can be perceived as final on the relevance of neuroscientific studies on cognitive processes of the psyche. According to the researcher, "neurology is a laboratory science covering various levels of analysis, namely, from molecular genetics to behaviour. One designs experiments at each level of analysis to answer empirical questions about interesting phenomena. Understanding the nature and structure of experiments in neurology is fundamental to assessing the quality of the evidence obtained from such experiments and the types of statements supported by the data" (Sullivan, 2015). Also, Sullivan (2015) identifies two key sub-branches in this regard, such as cognitive neurology and cognitive neurobiology. It confirms the need to single out the module on cognitive neurobiology and modern ideas on higher nervous activity of humans.

On the other hand, the results of our theoretical analysis of scientific sources on the importance and place in the educational process of interdisciplinary links allow one to conclude that for the effective formation of scientific competence of future psychologists in higher education in the discipline "Updates of modern neurobiology It is important not only to demonstrate interdisciplinary links by the teacher, but also to involve students in their search.

However, the experience of our own pedagogical activity forces us to agree with the opinion of Burzhinskaya (2007) about the inefficiency of independent search by students of interdisciplinary or intradisciplinary connections at the initial stages of learning. Therefore, the process of forming the ability of students of psychology to independently search for interdisciplinary links in the process of learning the discipline "Fundamentals of Modern Neurobiology", we will begin using the findings of Burzhinskaya (2007) on the expediency of the gradual formation of such an ability. Thus, according to the researcher, you must first teach students to characterize the object of several of the most important aspects that correspond to the basic teachings of a particular science, gradually involving them in finding more connections not only intradisciplinary but also interdisciplinary, which will automatically lead to ability of students to independently find interdisciplinary connections of the analyzed objects and phenomena.

Conclusions

Thus, the subject of study of the discipline "Fundamentals of modern neurobiology" are: hierarchical subordination and interaction of the central nervous system; nervous processes that occur in its higher parts and ensure the fluidity of human behavioral reactions; neural bases of mental processes; age-related changes in the human body and neurobiological mechanisms of dysfunction of its nervous system, higher nervous activity and sensory systems, and its purpose - to deepen and systematize previously acquired by students of psychology scientific knowledge of modern ideas about physiological mechanisms of mental activity and behavior, causes and neural mechanisms of basic psychopathologies.

The list of recommended literature, which is a compulsory component of the curriculum in any discipline, including "Fundamentals of Modern Neurobiology", is formed by us taking into account its purpose, student needs and current advances in neurobiological sciences.

A factor that contributes to the transformation of the content of natural science training of future psychologists in higher education, taking into account current trends and the current state of development of neurobiological sciences, is an integrative course "Fundamentals of Modern Neurobiology", which aims to deepen and systematize -psychologists of natural science knowledge of modern ideas about the physiological mechanisms of mental activity and human behavior, the causes and mechanisms of the main psychopathologies. The course consists of three modules: "Neurobiological essence of human communication with the environment", "Cognitive neurobiology and modern ideas about higher nervous activity", "Neurobiological aspect of age-related changes and mechanisms of disorders of the nervous system, higher nervous system and sensory systems" , which will ensure the end-to-end performance of the outlined tasks and the formation of a holistic system of modern professionally oriented neurobiological knowledge.

This approach to designing an integrative course "Fundamentals of Modern Neurobiology" allows a lecturer of higher education to spend more time studying more complex topics of the course and promotes the formation of students-psychologists creative activity, perseverance, desire for scientific self-development, self-education and self-improvement and skills to independently search for the necessary scientific information, to understand and realize its subject area, to operate the natural-scientific conceptual and categorical apparatus, to analytically-critically process,

analyze and generalize natural-scientific information from various sources and to formulate reasoned conclusions.

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