

CURRENT CHALLENGES AND PROBLEMS IN TEACHING PATHOPHYSIOLOGY IN UKRAINE – ANOTHER REACTION TO CHURILOV'S PAPER

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SUMMARY

Pathophysiology in Ukraine has rich traditions and achievements in the scientific areas, as well as in teaching academic discipline. Its history, the main Ukrainian scientific schools and their famous representatives are briefly described. The content of existing study program, the main approaches to teaching, and some methodological and organizational problems needed to be solved are characterized. The necessity and usefulness of developing and implementing the three separate courses of discipline (Essential, Clinical and Advanced Pathophysiology) are substantiated. The place of Pathophysiology in the training of physicians with different kinds of their future activity is discussed. Relation of teaching Pathophysiology to Translational and Personalized Medicine is tried to be shown.

Key words: history of medicine – medical education – pathophysiology – clinical pathophysiology – translational medicine – personalized medicine

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Introduction

Over the last decades Pathophysiology as a science and an academic discipline has been going through a very confusing time. Nowadays it faces a plenty of important problems caused by the rapid advances in both fundamental biomedical sciences and clinical medicine. The main questions standing in front of the pathophysiology are about vague perspectives of their science and curriculum discipline. There are a wide range of views and opinions: from "to be or not to be" to acceptance of leading integrating role of Pathophysiology in the development of so-called Translational Medicine.

A comprehensive analysis of existing challenges cannot be carried out without bearing in mind the historical approach which has been perfectly used by Churilov in his solid review (Churilov 2015). The experience gained in various countries is very important for searching and finding the answers to many questions of teaching Pathophysiology for future doctors (Gamulin 2003, Churilov 2009, Kovač 2010, 2014a,b, Churilov et al. 2014, Neuparth & Rendas 2016). It concerns organization of training, studying programs content, methodology, etc. Ukrainian Pathophysiology is world-famous for its scientific schools and is rich in educational traditions. It has always been characterized by innovative approaches to solving all problems, which are relevant at various times.

A little bit of history

For a long historical period, Ukraine was a part of the Russian Empire, and later - up to its independence -

of the Soviet Union. Hence, history of Ukrainian Pathophysiology was closely intertwined with history of "the metropolis". That is why some Russian scientists consider all academics, who was born and (or) worked in Ukraine in imperial times, to be representatives of the Russian Medicine. This concern, in particular, the famous pathophysiology mentioned in Churilov's review, namely: V. Podvysotskiy, N. Kozlov, N. Hrzhon-shevskiy, V. Lindeman, A. Bogomolets, N. Zajko.

There existed some historical centers of developing Pathophysiology in Ukraine. Those were Kiev, Kharkov and Odessa, where first autonomous chairs of General Pathology were established at medical faculties of universities in the second half of the 19th century (Zajko et al. 2015). Here, in these cities, the pleiad of outstanding scientists who formed the well-known schools of pathophysiology, grew up.

The founder of the Kiev school was Vladimir V. Podvysotskiy (Ukrainian: Volodymyr V. Pidvysotskiy) (Figure 1). His scientific works were devoted to the problems of regeneration in various parenchymal organs (liver, pancreas, salivary glands, kidneys), he studied general patterns of infectious process (in particular a role of reactivity in its development), and some questions of epidemiological research. Being the foremost teacher, he wrote the first Imperial Russian textbook in Pathophysiology. Among the best-known Podvysotskiy's followers were such scientists as A. Bogomolets, D. Zabolotny, I. Savchenko, L. Tarasevich. The first two held in their time the post of the President of Ukrainian SSR Academy of Sciences (Zajko et al. 2015).



Figure 1. Vladimir V. Podvysotskiy (1857-1913)

Legend: V.V. Podvysotskiy was born in Chernigov Region (Ukraine), graduated from the Medical Faculty of the St. Vladimir Kiev Imperial University (1884), was Head of the Department of General and Experimental Pathology in this University (1887-1900), Dean and Head of the Department of General Pathology in Novorossiysk University (Odessa) (1900-1905), Director and Head of the General Pathology Department of the Imperial Institute of Experimental Medicine in St. Petersburg (1905-1913).



Figure 2. Alexandr A. Bogomolets (1881-1946)

Legend: A.A. Bogomolets was born in Kiev, in Lukyanovskiy prison, where his mother, Sophia Bogomolets, served sentence for political reasons. He was educated in the family of his grandfather, graduated from the Medical Faculty of Novorossiysk University in Odessa. At the age of 29 years he headed the Department of General Pathology at the Faculty of Medicine created in Saratov University, and in 1924 he headed the Department of the 2nd Moscow Medical Institute and at the same time was the Director of Institute of Hematology and Blood Transfusion. In 1930 he moved to work in Ukraine, where during the rest of his life was the President of the Ukrainian SSR Academy of Sciences.

Alexandr A. Bogomolets (Ukrainian: Olexandr O. Bohomolets) (Figure 2) worked in many areas of Pathophysiology (endocrine pathology, tumor growth, blood transfusions, ageing), but his favorite subject of research was related to "physiological system of connective tissue". He proved that this tissue not only supports other tissues, connecting various highly organized structures, but also plays a very important role in their functioning as well as in activity of organism as a whole. Besides the well-known mechanical and plastic functions it has a wide variety of others, including defensive and trophic ones.

Functional activity of connective tissue is a crucial factor for providing specific and nonspecific resistance of organism to infectious diseases, malignant tumors and many other disorders. In fact, features of the connective tissue determine constitutio corporis and actual age of the person. For this reason, A. Bogomolets tried to find effective methods for activating the connective tissue system. He achieved such effect using Antirreticular Cytotoxic Serum (ACS, or Bogomolets' serum) first developed by him in 1936. In small quantities, but not in large toxic doses, it stimulates the connective tissue enhancing a variety of cellular reactions against pathogens and supporting regenerative processes and wounds' healing.

A. Bogomolets was an organizer and the first director of the Institute of Experimental Biology and Pathology in Kiev (now Bogomolets Institute of Physiology). He also initiated establishment of Institute of Gerontology (now Chebotarev State Institute of Gerontology), Research Institute of Experimental and Clinical Oncology (now Kavetsky Institute of Experimental Pathology, Onkology and Radiobiology) and Institute of Endocrinology and Metabolism (now named after Komisarenko).

As a disciple of V. Podvysotskiy, A. Bogomolets himself created a world-famous scientific school of pathophysiologicalists. Among his prominent pupils were: N. Sirotnin (1896-1977), R. Kavetsky (1899-1978), E. Tatarinov (1892-1950), N. Gorev (1900-1992), V. Komisarenko (1907-1993), N. Zajko (1908-1991) (Figure 3).

At the initial stage, development of Ukrainian Pathophysiology was closely linked with the other two schools that had been formed in the Russian Empire: one, in St. Petersburg, founded by V. Pashutin (1845-1901) and the other, in Moscow, founded by A. Fogt (1848-1930).

In Ukraine, bright representatives of Pashutin's school were A. Reprev (Kharkov) and N. Ushinskiy (Odessa). The first of them headed the department of Pathophysiology of the Kharkov Medical Institute for 30 years (1895-1925). His scientific works were devoted to the problems of starvation, endocrine glands pathology, and heat and gases exchange disorders. Developing an experimental direction in endocrinology, A. Reprev created his own scientific school, which was represented by such names, as M. Pavlov, B. Shatsillo, D. Alpern, S. Genes, S. Leites and others (Klymenko 2009).



Figure 3. Famous representatives of A. Bogomolets' scientific school. 1 – N. Sirotinin, 2 – E. Tatarinov, 3 – R. Kavetsky, 4 – N. Gorev, 5 – V. Komisarenko, 6 – N. Zajko

Table 1. Famous representatives of Ukrainian Pathophysiology, who founded their own scientific schools

Scientists	Main areas of scientific research
Bogomolets Kiev School	
N. Sirotinin (1896-1977)	Role of organism reactivity and resistance in pathology. Hypoxia
R. Kavetsky (1899-1978)	Impact of organism reactivity on neoplastic process
N. Gorev (1900-1992)	Pathophysiology of cardiovascular system. Atherosclerosis. Ageing
V. Komisarenko (1907-1993)	Pathophysiology of endocrine system. Pathology of adrenal cortex
N. Zajko (1908-1991)	Nervous trophicity and neurodystrophic process
Reprev Kharkov School	
D. Alpern (1894-1968)	Pathophysiology of nervous system and neurohumoral regulation. Inflammation. Allergy
M. Pavlov (1882-1967)	Pathophysiology of endocrine and digestive systems
S. Genes (1898-1992)	Pathophysiology of endocrine system. Diabetes
S. Leites (1900-1972)	Pathophysiology of endocrine system. Disorders of lipid metabolism

Some of the successful A. Fogt's pupils also worked in Ukraine, they are: V. Lindeman in Kiev, V. Voronin in Odessa, A. Talyantsev in Katerinoslav (now Dnepr) (Mojbenko 2009).

At the same time, Ukrainian pathophysiologicals made a significant contribution to the development of science and higher education in Russia. Thus, in the Russian universities and research institutions worked for a long time above mentioned V. Podvysotskiy (St. Petersburg) and A. Bogomolets (Saratov, Moscow), as well as L. Tarasevich (Moscow), Savchenko (Krasnodar), and others.

The two major national pathophysiological schools and their main research areas are shown in Table 1.

Information about scientific problems being studied by pathophysiologicals of modern Ukraine can be found in Table 2.

Pathophysiology as an academic discipline in Ukraine. Its main problems

First autonomous departments of Pathological Physiology (General Pathology) in Ukraine were created in Kiev in 1869 by N. Hrzonshevskiy and in Kharkov in 1872 by I. Obolenskiy. Today, Pathophysiology is taught at all of 18 Ukrainian universities where students can obtain higher medical education.

Table 2. Scientific areas and problems being studied by the pathophysiologists of today's Ukraine

Directions and problems	Scientists
General Nosology	
Problems of disease essence, general etiology and pathogenesis	A.Gozhenko (Odessa), A.Mojbenko (Kiev, Bogomolets Institute of Physiology), O.Sukmansky (Odessa), A.Ataman (Sumy)
Typical Pathological Processes	
Inflammation. Cellular and humoral mechanisms of its pathogenesis	N.Klimenko (Kharkov)
Shock. Free radical and humoral mechanisms	V.Elsky, S.Zjablicev (Donetsk); A.Kubyschkin (Simferopol)
Immunological processes. Allergy	G.Butenko (Kiev, Institute of Gerontology), V.Chopjak, M.Reheda (Lviv)
Hypoxia. Mechanisms of damage and compensation	I.Mankovska (Kiev, Bogomolets Institute of Physiology), Yu.Kolesnik (Zaporizhia)
Ageing. Pathophysiological aspects	G.Butenko (Kiev, Institute of Gerontology)
Molecular genetic mechanisms of diseases and pathological processes	V.Dosenko (Kiev, Bogomolets Institute of Physiology), A.Ataman, V.Harbusova (Sumy)
Pathophysiology of Heart	
Endogenous mechanisms of heart muscle injury and cardioprotection	A.Mojbenko, V.Dosenko (Kiev, Bogomolets Institute of Physiology)
Mechanisms of coronary circulation disorders	A.Khomazyuk, A.Neshcheret (Kiev, Institute of Endocrinology and Metabolism)
Role of nervous autonomic imbalance in development of heart disease	Yu.Bondarenko, M.Khara (Ternopil)
Pathophysiology of Blood Vessels	
Role of mitochondrial factors and nitric oxide system in vascular smooth muscle lesions	V.Sagach (Kiev, Bogomolets Institute of Physiology)
Pathogenesis of arteriosclerotic lesions.	Yu.Byc (Kiev, Bogomolets National Medical University),
Mechanisms of vascular calcification	A.Ataman (Sumy)
Pathophysiology of venous vessels	V.Bratus (Kiev, Institute of Cardiology)
Pathophysiology of Digestion and Liver	
Pathogenesis of dentoalveolar apparatus, salivary glands and oral tissues lesions	O.Sukmansky (Odessa), V.Kostenko (Poltava)
Pathophysiology of stomach and intestines. Nervous and humoral mechanisms of digestive disorders	V.Michnev (Kiev, Bogomolets National Medical University), N.Kononenko (Kharkov)
Pathophysiology of liver. Mechanisms of its failure	N.Rykalo (Vinnytsia)
Pathophysiology of Kidneys	
Mechanisms of excretory and incretory disturbances and compensation in kidneys	A.Gozhenko (Odessa), N.Kryshtal (Kiev, Bogomolets National Medical University), Yu.Rohovyj (Chernivtsi)
Pathophysiology of Endocrine System	
Hormonal mechanisms of reproductive disorders	A.Reznikov (Kiev, Institute of Endocrinology and Metabolism)
Neurogenic mechanisms in pathogenesis of diabetes	Yu.Kolesnik, A.Abramov (Zaporizhia)
Pathophysiology of Nervous System	
Mechanisms of central nervous system motor functions disorders. Pathogenesis of epilepsy	R.Makulkin, A.Shandra, L.Godlevsky (Odessa)
Pathogenesis of neurodystrophic process	V.Michnev (Kiev, Bogomolets National Medical University)

In the past, students learned the discipline from textbooks, written by V. Podvysotskiy (1905), V. Lindeman (1910), A. Bogomolets (1921), D. Alpern (1938). In 1966, there appeared four volumes of "Handbook on Pathological Physiology" under the general editorship of the most prominent Bogomolets' pupil N. Sirotinin. This guide remains the first and the only edition of such kinds throughout the former USSR (Figure 4).

Since 1977 the textbook edited by another Bogomolets' pupil N. Zajko has become the main source of knowledge on Pathophysiology for native students. It

should be noted that this tutorial has been republished several times and translated into a number of European and Asian languages. Nowadays, the students can also use two volumes textbook as well as "Pathophysiology in Questions and Answers" both written by Zajko's pupil A. Ataman. Additionally, there are textbooks for various categories of medical students, e.g. for English-speaking ones (under the editorship of A. Kubyschkin & A. Gozhenko, and written by N. Simeonova & V. Mikhnev) and pharmacists (under the editorship of M. Reheda & A. Berezniakova) (Figure 5).

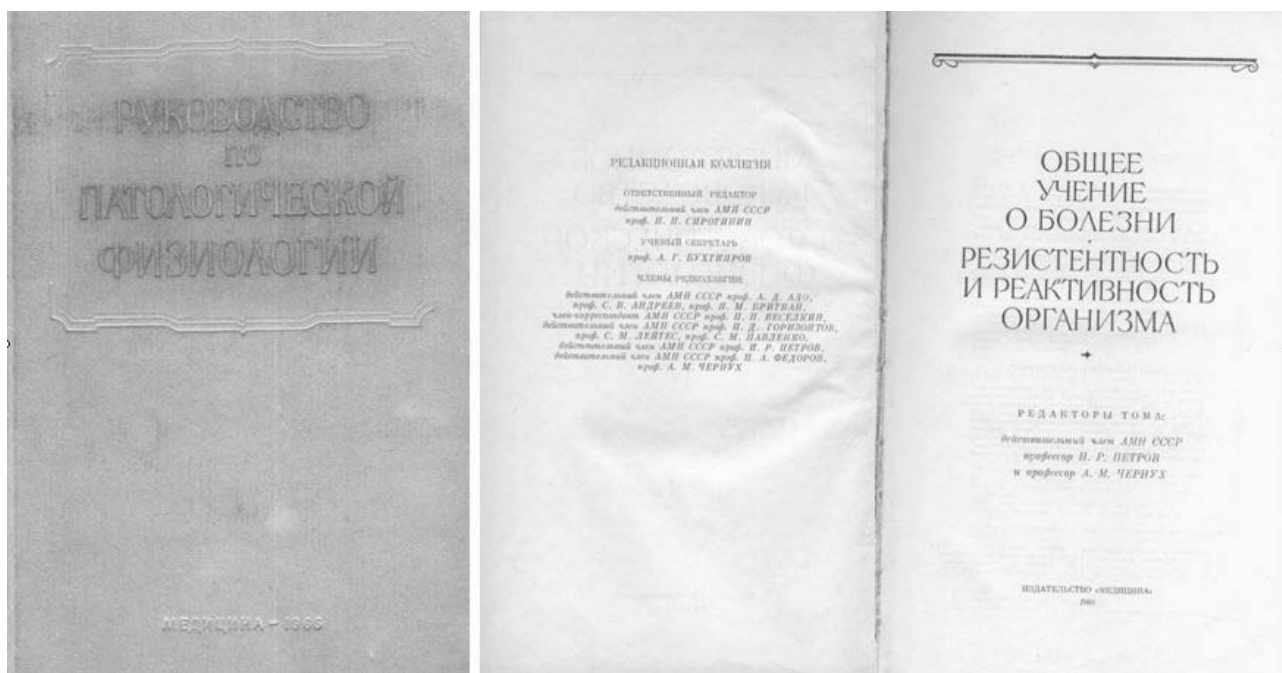


Figure 4. Multivolume Handbook on Pathological Physiology under the general editorship of N. Sirotinin (1966). Volume 1: General Teaching of Disease. Resistance and Reactivity of Organism

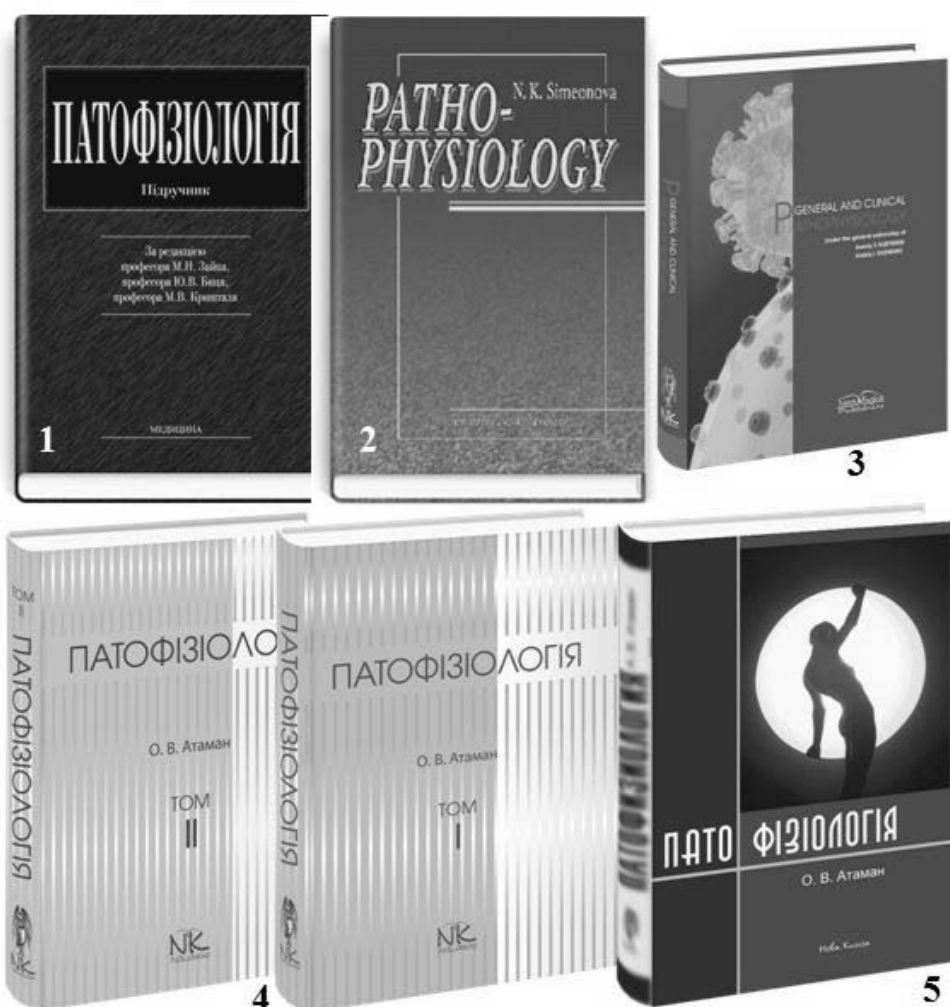


Figure 5. Contemporary Ukrainian Textbooks on Pathophysiology. 1 – edited by M. Zajko, Yu. Byts' & M. Kryshchal'; 2 – written by N. Simeonova & V. Mikhnev; 3 – edited by A. Kubyshkin & A. Gozhenko; 4, 5 – written by A. Ataman

Table 3. Typical study program on Pathophysiology for Ukrainian universities

Module 1. General Pathophysiology
<i>Substantive units (3 credits):</i>
<ul style="list-style-type: none"> ▪ General Nosology – general teaching about Disease, Etiology and Pathogenesis. Pathogenic effect of Environmental Factors. Role of Endogenous Factors in Pathology ▪ Typical Pathological Processes ▪ Typical Disorders of Metabolism
Module 2. Pathophysiology of Organs and Systems (Special, or Systemic Pathophysiology)
<i>Substantive units (4 credits):</i>
<ul style="list-style-type: none"> ▪ Pathophysiology of Blood System ▪ Pathophysiology of Cardiovascular and Respiratory Systems ▪ Pathophysiology of Digestion, Liver and Kidneys ▪ Pathophysiology of Regulatory (Endocrine and Nervous) Systems

In accordance with a current typical program on Pathophysiology (2014), this academic discipline is divided into two parts (modules): (I) General Pathophysiology and (II) Pathophysiology of Organs and Systems (Special Pathophysiology). The first of them includes three and the other one – four substantive units (3 and 4 credits respectively) (Table 3).

Describing the substantive and methodological sides of Pathophysiology teaching in Ukraine, it should be noted a number of their features, somewhat similar and somewhat special when compared with other countries.

Course of Pathophysiology, which is taught in the 3rd year of study, always was and now remains to be *at the centre* of medical specialists training. That is because it deals with the most general laws governing the beginning, development and outcome of a disease. A physician of any specialty must know and understand these laws and common patterns of typical pathological processes, that is why Pathophysiology is considered to be the theoretical basis of clinical medicine.

On the other hand, all of the academic disciplines, which students learn during the first two years, are subordinated to the comprehension of essence of disease. Since a disease can be considered as a result of interaction of initially healthy organism with various environmental factors, so for its understanding it is necessary to acquire knowledge about normal properties of an organism as well as the features of exogenous agents, which might become pathogenic. That is why we have divided all disciplines needed to successful learning of Pathophysiology into 2 groups (Figure 6). Insufficient knowledge of these curriculum disciplines makes our educational goal unattainable.

Traditionally, domestic Pathophysiology is considered to be the theoretical basis of clinical medicine, or in other words *philosophy of medicine*. Hence, it has two facets: one is informative itself and the other gives

overall perceptions about a disease as a general, in fact, philosophical category. In contrast to many other countries, the second side of Pathophysiology is of particular importance in teaching this discipline in Ukraine. Thus, even in modern Ukrainian textbooks, the issues of general nosology (concepts of disease, etiology and pathogenesis) take up more than 5 per cent of teaching material, while many western tutorials do not deal with those questions at all or consider them too briefly.

In the scientific community of Ukrainian pathophysiology, discussions of philosophical problems of medicine are held permanently over many years. In particular, they concern such problems as general theory of disease, pathogenesis and sanogenesis, endogenous mechanisms of pathogenesis, etc. (Ataman 2010, Goshenko 2015).

For having general notions about disease, integration with other academic disciplines, studied by the 3rd year students at the same time, is of great importance. For example, various aspects of peptic ulcer disease are taught at different departments: Pathophysiology (etiology and pathogenesis), Pathological Anatomy (morphologic characteristics of ulcer and its complications), Pharmacology (etiological and pathogenetic treatment), Propaedeutics of Internal Diseases (manifestations and diagnosis), and General Surgery (surgical aspects of ulcer and its complications). In fact, one and the same object (but not 5 different) is studied by student from every angle. And here, Pathophysiology can and must help him to integrate knowledge to get a holistic view of this disease. Therefore, the *integrative role* of Pathophysiology is another very important feature of our discipline, and the attempts to reunite it with Pathological Anatomy (and why not with Normal Physiology, Pharmacology?) are, in our opinion, destructive and not dictated by a real necessity, but solely by political reasons. Fortunately for us, there is no such trend in Ukraine.

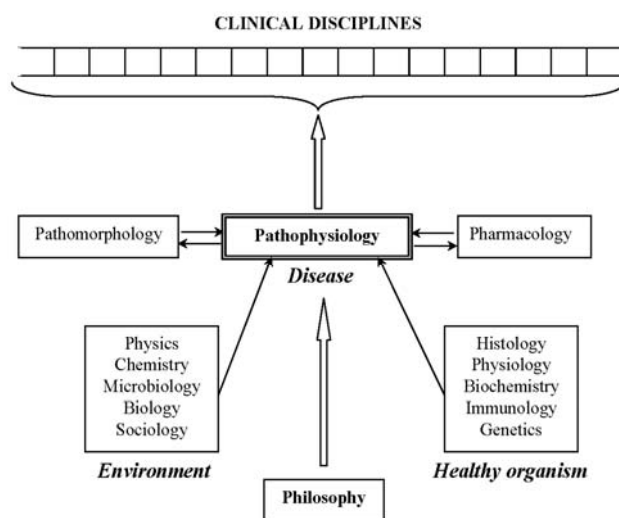


Figure 6. The central place of Pathophysiology in future doctors training. Its relation to other disciplines

Pathophysiology is rather the first academic discipline, which requires from students not so much memorizing and reproducing facts as thinking skills to apply their knowledge in different fields of science for understanding and explaining what is happening in a sick organism. Accordingly, the main principles, which a teacher should be guided by, are of especially great importance.

We believe some approaches to be basic for teaching our discipline:

- The first one is a consideration of disease and pathological processes on different levels of biological organization - from molecular to the whole organism level. Essentially, this is a combination of historically basic concepts of disease (atomistic, humoral, cellular, neural), but given the latest advances in each of these directions.
- It is important to understand that disease is a manifestation of unity and struggle of two opposites: actual pathological things (injury, destruction) and protective physiological ones (defense, compensation). Analysis of any disease and pathological process should be carried out precisely from these positions. Importance of this statement can be demonstrated by the fact that one of the symbols of native pathophysiologists is the antique sculpture "Laocoon and his sons".
- Among endogenous conditions of the beginning, development and outcome of the disease, organism reactivity and its resistance are of great significance. Thus, the essence and mechanisms of defensive compensatory reactions must always be the center of attention in the study of each disease and pathological process.
- For the formation of clinical reasoning, it is very important to reveal the cause-and-effect relationships in pathogenesis. That's why these questions are cornerstones of any section and subject studied by students.
- Understanding the significance of Pathophysiology for clinical practice, we pay particular attention to the mechanisms of basic clinical signs (symptoms and syndromes), which pathological processes and diseases are manifested by. Moreover, the general principles of pathogenetic treatment and correction of disturbances occurring in the organism are substantiated.

Problems, standing now in front of the native Pathophysiology as an academic discipline can be divided into some groups.

A problem of discipline's content

The fundamental life sciences are developing very rapidly, more than ever before. A deep penetration into the molecular and molecular-genetic mechanisms of diseases and pathological processes, in particular the formation and development of Molecular Pathology,

needs stating the question about the extent to which the study programme should be filled with new information.

Some years ago, we proposed an idea of "balanced development of native Pathophysiology" (Ataman 2011). It meant the permanent filling of the discipline with new scientific facts, their systematization and consolidation, on the one hand, and saving (and even development) the traditions of native pathophysiological school, which paid great attention to the philosophical and ideological bases of future physicians training, for the formation of scientific thinking skills in students, on the other hand.

As it turned out, there were organizational and methodical difficulties in the implementation of this concept. It was not possible to increase significantly the amount of study material within the limited curriculum credits. At the same time, there arose a problem, how to teach new, and difficult for learning, information, that requires from students initially deep fundamental knowledge, how to make it easily understood. In other words, there are three questions needed to be answered: what to teach, when to teach, and how to do it. Below, we are trying to find some answers to all these questions.

Methodological problems of teaching

Not so long ago, experiment was an important element of teaching, both at practical classes and lectures. None of practical training was carried out without experiments on laboratory animals and every student had to conduct one of the main experiments at the exam. Unfortunately, today's bioethical requirements and our organizational difficulties have closed out experiments as a kind of learning activity for students. The attempts to substitute a real experiment with its video registration and its further demonstration or with virtual one created by means of computer programs cannot be effective. Indeed, classical Cohnheim's model of inflammation doesn't give much new information about this process but it strongly affects the subconscious mind, fulfilling an important motivational role and encouraging students to study the discipline. In our opinion, Pathophysiology without an experiment is like a dish without spice: calories are the same but it doesn't taste so good.

It should be noted that among the Ukrainian pathophysiologists there are teachers who deny any role of study experiment in modern conditions and offer to substitute it with practical work on the analysis of clinical examinations results. Of course, the elements of such analysis can and must be used at practical classes but in full size – only later while the studying of Clinical Pathophysiology at the undergraduate level.

Certainly, Ukrainian pathophysiologists are well aware of the experience of their foreign colleagues and are willing to test new proposed methodological approaches to teaching in our country. Particularly it concerns the etiopathogenetic clusters method and the other ones which are successfully introduced in Zagreb University (Kovač 2014ab).

We are firmly convinced that today's methods of teaching must comply with the latest technical capabilities and widely used various computer technologies, electronic gadgets, Internet, etc. All these tools enable us not only to propose new methodical modes, but also to create favorable conditions for more extensive sharing of experiences and selecting the most appropriate training programs for students.

As an example of successful work in this area, training programs of Prof. V. Dosenko (Kiev), which use educational platform DESK (Development, Education, Science, Knowledge) (<http://desk.ua/course/pathophysiology/>) and resource *molecula.club*, offering a study of Pathophysiology by separate thematic blocks (<http://www.molecula.club/>), can be named. The pathophysiology of Sumy State University have developed a full course of discipline with a free access through the system Open Course Ware (OCW) (<https://ocw.sumdu.edu.ua/content/792>).

Organizational problems

The most acute is the problem of students' knowledge evaluating. It covers the following questions: (a) who, how and when should evaluate students' knowledge, (b) functions of scores in the studying process, (c) assessment criteria, (d) to what extent scores comply with the quality of specialists' training, (e) the role of subjective factor in evaluating, (f) conflict of interests.

Today, medical students training is assessed in practical classes (initial and final levels), when testing each of substantive units (concluding grading), on the exam (total score), and, finally, on the license exam "Step 1" (fundamental disciplines), carried out by Testing Center of Health Ministry of Ukraine. Unfortunately, getting good grades, but not acquiring deep knowledge, has become for many students the main purpose of studying. To that end, they often use the ways contradicting the law and giving rise to a conflict between students and teachers.

Classical methods of examination (conversation with the professor answering the examination questions, performance of practical assignments) are now being

replaced by computer (or paper) testing. In these conditions, preparing students for tests are often carried out not systemically with usage of textbooks, and is based solely on the memorization of a large database of test questions and answers with 1 correct of 5 ones.

We believe that testing by means of computer programs is not quite right for Pathophysiology. It can be effectively applied to the evaluating of disciplines, based on a large number of concrete facts which student must have memorized (Anatomy, Biochemistry, Microbiology, Pharmacology, etc.). As it concerns Pathophysiology, there are not so many facts needed to memorize only, and, on the other hand, a lot of issues that must be explained by students can have ambiguous answers. That is why to compose a large base of adequate test questions on Pathophysiology is a very difficult task. In this regard, one of the highest priorities for us should be developing or adapting computer programs to determine the student's ability to thinking, the skills of usage of their knowledge for explanation what is happening in the sick organism, what etiology and pathogenesis of pathological processes and most common diseases are.

Does today's clinician necessarily need the deep fundamental biomedical knowledge?

The main challenge standing in front of us may be designated within the question: Pathophysiology as a science and as an academic discipline: how far are they now from each other.

The content of our discipline has always been dynamic, it has been replenishing with all the latest achievements of science, although with a certain lag, which can be explained not only by technical issues (preparation and publication of new teaching materials, textbooks, etc.), but also by the need for validation and recognition of the new discoveries, inventions, etc.

Nowadays, the fundamental biomedical sciences are developing so rapidly, both in depth and in width, that there arises a gap between the level of current scientific knowledge and the content of our discipline (Figure 7).

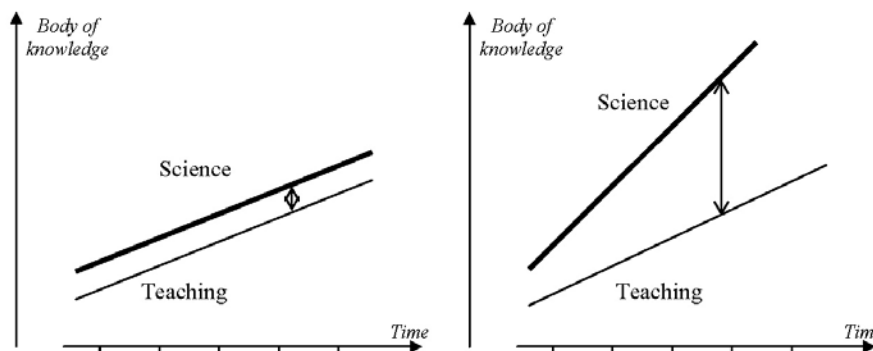


Figure 7. The lagging of teaching Pathophysiology from the level of biomedical sciences earlier (first graph) and today (second graph)

Therefore, there is a problem what to do: in spite of everything, to continue saturating the discipline with new scientific information, creating and publishing multivolume editions (textbooks, guides, manuals, etc.) and increasing the number of training hours, or to limit its scope by transferring some traditional sections to geneticists (the role of heredity in pathology, molecular genetics mechanisms of disease), immunologists (immunopathology, allergy), biochemists (typical metabolic disorders). It is obvious that both variants are defective and not feasible.

We see the solution of this problem in response to the question: who and to what extent needs the advanced knowledge in Pathophysiology.

First, it must be stated that a physician in the past and a doctor today differ substantially not only by the ability of medicine, but also by the nature of their activities (Figure 8).

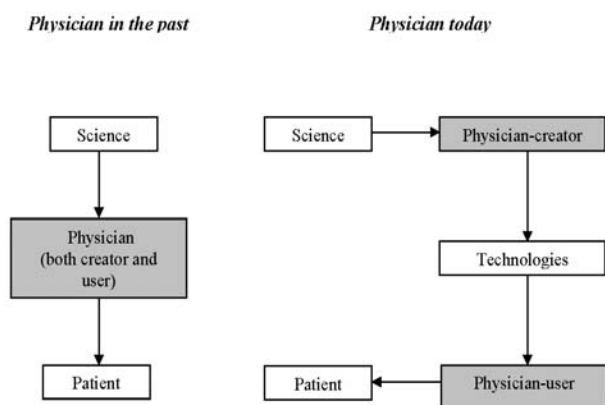


Figure 8. Character of physician activity in the past and in the present

The medical profession in the past had to be creative because of the limited medical knowledge. Practicing doctor had simultaneously to be a physician-researcher who was looking for ways how to help the patient, he was forced to read constantly scientific literature and analyze his own medical activity to offer and improve the methods of diagnosis and treatment. All his achievements were based on his knowledge, skills, experience, and intuition.

In contrast, today's physician is a user of modern medical technologies and his creativity is minimized by the existence of mandatory standards and protocols for diagnostics and treatment. Thus, there arises the question: how deep must the user of these technologies know their essence and processes underlying them. Everyone, at work and at home, uses personal computers, gadgets and various programs. In doing so, the majority of us have no idea about the physical processes occurring in these devices and their components, does not know the basics of programming, etc. But this does not prevent the effective using of computer technologies to perform the tasks facing us.

Is it possible to become a good surgeon-oncologist, having not much ideas about the finest molecular genetics mechanisms of cell transformation in cancer, about profound mechanisms of infiltrative growth and metastasis, etc? Apparently, it is possible. Thus, who needs such knowledge? Obviously, it is necessary for those physicians who will develop and propose new technologies for detection and treatment of malignant tumors, i.e. doctors-researchers, scientists.

Hence, we have to come to an understanding that teaching Pathophysiology for two different categories of doctors: physicians-practitioners and physicians-researchers must be also different.

In our opinion, there should be formed three separate courses of Pathophysiology but tightly connected with each other (Figure 9). First one might be named as *basic course, or Essential Pathophysiology*. In its content, it should be a well-established discipline (just as Anatomy, Histology, Biochemistry, and Physiology), in which scientific evidences and theoretical ideas (philosophy of medicine) have to be balanced. After completing its formation, this basic course might start from the cellular level of organism organization (in analogy with Normal Physiology). Everything that is occurring below it (subcellular and molecular levels), even in conditions of pathology, should be taken outside the scope of this course. Teaching of Essential Pathophysiology, as now, should precede the clinical disciplines and remain at the centre of medical students training (see Figure 6).

Depending on the direction, in which further studies of medical students will continue, teaching of Pathophysiology might follow two ways after receiving the basic clinical training.

The course of *Clinical Pathophysiology* should be offered to future practical physicians. Having studied the clinical disciplines and continuing to do it, students, dealing with specific clinical cases at the bedside of patients, must learn to analyze possible causes and mechanisms of disease development, the origin of symptoms and syndromes identified in a *particular patient*.

The second direction can be called *Fundamental, or Advanced Pathophysiology*. It must be a constantly developing discipline, which absorbs all the latest achievements of medical and biological sciences, especially Molecular Biology and Genetics, Immunology, Pathochemistry, and Pathomorphology. As opposed to the basic course, its content has to be much more dynamic. It should be studied by those students who will be involved in scientific activity, i.e. develop and improve the modern medical technology.

Thorough fundamental training of doctors-researchers, especially on Pathophysiology, is very important from the viewpoint of *Translational Medicine*, the main goal of which is to put newest research results and technologies into practice by uniting the efforts of theoretical and clinical medicine.

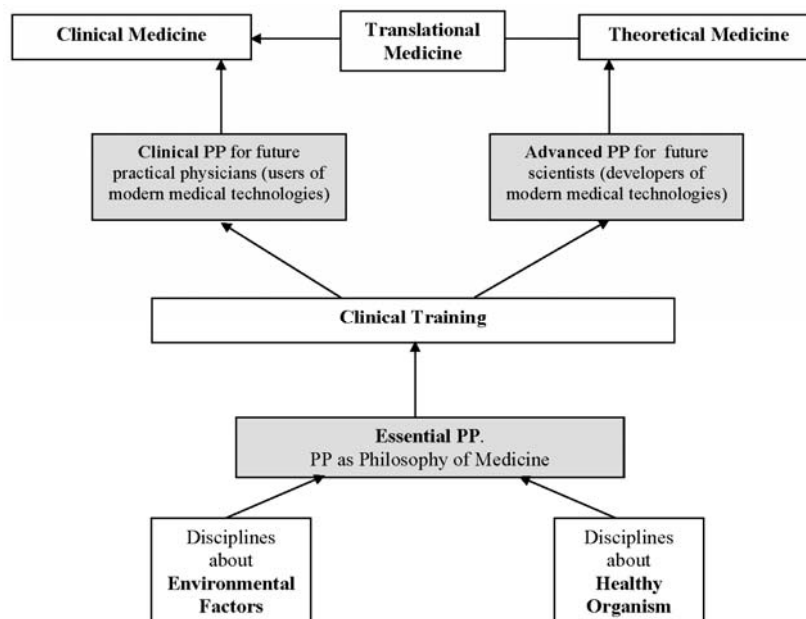


Figure 9. Three proposed courses of Pathophysiology (PP) and their place in the system of future doctors training

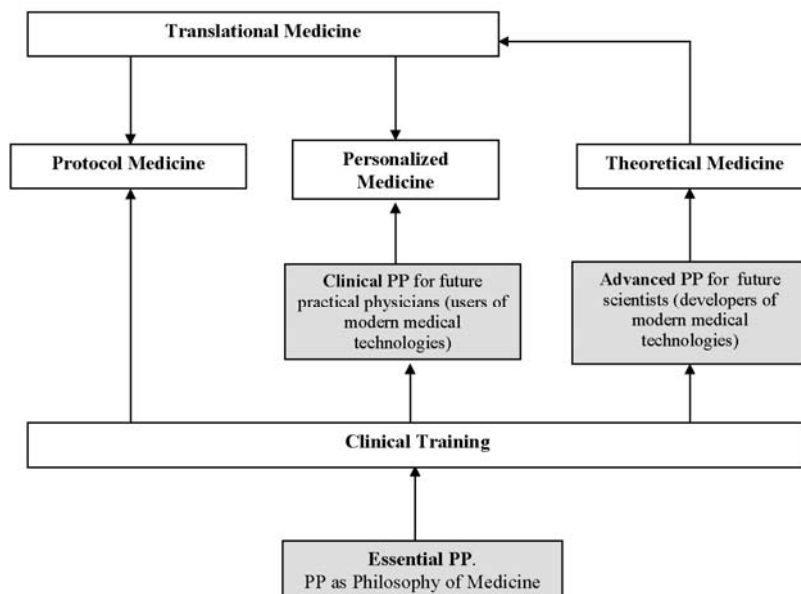


Figure 10. Differentiated approach to the training of physicians with different kinds of activity

Presented in Figure 9 scheme can be complicated when taking into account that training of practitioners might be conducted in two strategic areas (Figure 10). The first of them is so-called *Protocol Medicine*, which provides medical activities exclusively on the prescribed algorithms of diagnostic and treatment protocols that have been created and based on the findings of Evidence-Based Medicine. For training such kind of physicians, the basic course of Pathophysiology is probably quite enough.

If it is about the other strategic direction – *Personalized Medicine*, requiring treating not a disease but a particular patient, it is obvious that a physician needs both Clinical Pathophysiology and Advanced one, based on modern scientific achievements (Gamulin 2016).

Translational Medicine, in which a central integrating role must belong to Pathophysiology, will be equally needed both Protocol and Personalized Medicine. That is why development of Pathophysiology as a science and its upgrading as an academic discipline is and will always be relevant.

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