

## INTEGRATION OF EDUCATIONAL AND RESEARCH ACTIVITIES OF MEDICAL STUDENTS

(EXPERIENCE OF THE MEDICAL FACULTY OF SAINT PETERSBURG STATE UNIVERSITY)

Aleksei V. Balakhonov, Leonid P. Churilov, Mikhail V. Erman, Aleksandr N. Shishkin,  
Lyudmila A. Slepikh, Yuri I. Stroeov, Vladimir J. Utekhin & Natalia Y. Basantsova  
*Saint Petersburg State University, Saint Petersburg, Russia*

*"...so the medical doctor should be a surgeon and internist, as well as a naturalist,  
for without knowledge of natural sciences reasonable Medicine is unthinkable."  
S.P. Botkin (1832-1889), one of the greatest Russian physicians*

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### SUMMARY

*The article is devoted to the role of research activity of the medical students in higher education of physicians. The teaching of physicians in classical universities and specialized medical schools is compared. The history of physicians' training in Russia in imperial, Soviet and post-Soviet periods is reviewed and compared to development of higher medical education in other countries. Article gives the the description of all failed attempts to establish a Medical Faculty within oldest classical university of Russia, crowned by history of last and successful attempt of its establishment. Authors' experience of adjoining education and research in curriculum and extra-curricular life of this Medical Faculty is discussed. The problems of specialization and fundamentalization of medical education are subjected to analysis. Clinical reasoning and reasoning of scholar-experimentalist are compared. The article reviews the role of term and course papers and significance of self-studies and graduation thesis in education of a physician. The paper gives original definition of interactive learning, and discusses the methods and pathways of intermingling the fundamental science and clinical medicine in medical teaching for achievement of admixed competencies of medical doctor and biomedical researcher.*

**Key words:** *medical education – fundamental science – clinical medicine – competencies – course paper – graduation thesis – syllabus – curriculum – history of medicine*

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### Introduction

While discussing issues of higher education in Russia it is common to write about the problem of scientific substantiation of new strategies for the professional education development, to speak on the modernization of educational traditions/innovations ratio, to emphasize improving links between education and industry, science, social institutions. Although everyone agree that the new education requires new approaches to the selection and systematization of knowledge, the creation of fundamental courses, the revaluation of values and the very nature of interdisciplinary relations.

These statements are undeniable themselves, but the problem of improvement of modern higher education requires a scientific understanding of the ways of its particular implementation in educational practice – here and now. Ill-conceived and hasty desire to connect, for example, tasks of fundamentalization of education and requirements of professional training will inevitably lead not only to increased academic load on students, but also to the emergence of a "patchwork quilt" where each patch individually looks beautiful, but as a whole a quilt doesn't please one's eye. It is obvious that the higher education cannot teach/learn everything. Then

naturally, the question arises: What should be taught first? Maybe once again we shall remember the principle of the Nobel Prize laureate Werner Karl Heisenberg (1901–1976), who saw education mainly as a permit to the informal corporation of equal, critically thinking people and said to his schoolmates from Maximilian School of Munich, while celebrating its jubilee: "*Education is what remains with you after you forget everything you were taught*" (Heisenberg 1987).

However, scientific basis of *educational content* selection nowadays plays a special role, because this one specifically determines the direction of search of the new educational methods and the control of students' knowledge.

### Medicine and Natural Science

The authors of this paper are not fully aware of how these questions are solved in the humanitarian, technical or mathematical sciences. They are more familiar with medical education that encounters contradictions, because of the inadequacy of graduates' competence level for the modern medical and research practice (Balakhonov 2004a,b, 2006a,b, Churilov et al. 2009, 2014). Therefore, we will focus on physician's education.

Nevertheless, the authors hope that sharing their views on medical education can also be of some interest for those who teach other specialists.

The necessity of extension and optimization of medical training formats is caused by critical requirements. Medicine of the nearest future has all the chances to fundamentally expand its capabilities by using impressive achievements of Biotechnology, Genomics, Proteomics, Bioinformatics, disease modelling, high-precision robotic microsurgery, stem cell technologies, precise targeted genome editing, and so far. Achievements in the fields of Molecular and Cell Biology, Molecular Genetics, Physico-Chemical Biology and Immunology, progress in living systems' subtle structure and function research has created new opportunities for understanding of etiology of diseases, their diagnosis and treatment.

In the "Atlas of new professions", published recently in Skolkovo research cluster, in the section "Medicine" it is expected that prior to 2020, for example, several new medical specialties will appear, such as: genetic counselor, clinical bioinformaticist, molecular nutritionist, healthy senility counselor, network medical doctor, who will be capable to verify diagnosis on-line. After 2020 authors expect coming of personal medicine experts, specialists in cyber prosthetics, IT-geneticists (specialists, who are programming genome under given parameters), and medical robot operators (Atlas 2014).

Although we do not believe in Clinical Medicine devoid of direct patient-doctor contacts, we are not going to discuss these assumptions or suggest our own. We just note that medical graduates should be able to use in their medical practice achievements of the modern science. Educational course is determined by those health objectives that "doctors of tomorrow" should solve. What now seems real only for individual clinics in the whole world or for several unique specialists in several years may become as routine method, available albeit not for all, but for many members of the medical community. Alas, "generals always prepare to previous wars, not to future ones" – the same is true about disease fighters.

Recall, for example, what miracles have recently seemed in vitro fertilization or genetic engineering, how we have read science fiction novels about robotic surgeon, saving a cosmonaut during space expedition. Meanwhile, nobody takes medical education from duties to convey to the graduates the knowledge and skills to solve common professional problems, to act correctly in certain situations.

The conservatism of medical education leads to the quite understandable conflict between the existing mission to train young doctors in clinical reasoning with repeatedly practiced, but often outdated and not evidence-based methods of disease prevention, diagnosis, treatment – and challenges brought in by scientific

progress. The later call for active integration of natural science advances into clinical practice, in order to enhance the understanding of human disease and health.

The resolution of this contradiction obviously represents one of the most complicated questions for medical education: A harmonious blend of teaching the necessary professional skills and receiving fundamental natural science knowledge has to be realized within a relatively short period of medical curriculum.

Medical doctor should not be an optimistic layman in science at least to maintain a reasonable care and be cautious in clinical practice (Churilov & Stroev 2016). But if his knowledge about advanced scientific breakthroughs was gleaned from mass-media and not from a University course of natural sciences, a physician would not get any role regarding scientific progress except that particular enthusiastic layman. Through the history of medicine doctors who were supporters of some new natural science breakthroughs often run ahead, hurry to apply one or another remedy, discovery, method and occasionally the irreparable harm caused by dozens of such energetic laymen became clear after the years of application some not scientifically studied phenomena. Take, for example, mass treatment of adenoids and thymomegaly in kids with x-ray irradiation, fashionable in USA in the 20-30-ies of the last century, or the use of compounds with thorium as a radiopaque substance (they gave very good contrasting!). In the beginning of Radiology, medics did not stop on time promotion of radium as a means of improvement of water and even recommended radium plates sewn into underwear for raising potency (Churilov & Stroev 2016).

The Medicine – is *not only science*, although it is based on science. It includes various other non-scientific elements of human culture related to health and disease. Among them are pieces of Law, Morals, Business, Arts, Mythology, Crafts and even some element of Quasi-Religion. Because of that mosaic load, Medicine never can be as dynamic as natural science is. Meanwhile, the rapid development of science generally and Biology particularly in the second half of the last century lead to the fact that clinical and theoretical Medicine began to lag behind the current state of the science. The great medical classics of the XIX and first half of XX centuries have made fundamental scientific discoveries, using *the same tools as in routine medical practice*: The light microscope, Goryaev's camera for blood cell count, the Riva-Rocci apparatus for blood pressure measurement, electrocardiograph, plethysmograph, etc. A physician like that could be (and by measure of his intellect and motivation – really was!) both a practitioner and a scientist – after studying at the Medical Faculty of University, or after combined training at the Department of Physics and Mathematics at the Faculty of Natural Science and then – in the medical school. The bright examples among alumni of Saint Petersburg

University were ingenious physiologist Ivan P. Pavlov (1849–1936), or an outstanding internist and biophysicist, inventor of impedance plethysmography Aleksei A. Kedrov (1906–2004). However, nowadays it is hardly possible! The modern Biomedicine uses many tools and techniques that are not normally used in everyday health care practice, and take long time and specific education to master.

### **Training of physicians in Russia: Soviet reform and post-Soviet heritage**

In Russian Empire of XIX century, like in other leading countries of that epoch, medical doctors were trained exclusively in classical Universities, with one exception of Emperor's Military Medical Academy. The Soviet power, which substituted Tsars, needed many collectives of practical physicians ready to function as soon as possible, regardless of their academic titles and noble sounding scientific degrees. To hold a title of M.D. was no longer important, Soviet medical school graduates conferred upon so-called "Vrach diploma". Although their professional competence was not lower and as a rule even higher than under old system, their special qualification was no longer supposed to be academic degree, just a professional certificate, assuring that a specialist holding it has the right to repair "human instruments" of global communist construction (Churilov et al. 2009).

The Soviet Union had developed very effective system of health care (as regards to its costs/effect ratio). Moreover, it was available gratis to all citizens even in most remote corners of a country. However, there was no place for private medical practice in that system: Doctors were "collectivized" into a kind of medical "kolkhoz" named polyclinics (versatile outpatient departments). Moreover, government of the USSR since academic year 1930-31 put medical education beyond classical universities – into specialized autonomous medical schools (called Medical Institutes, after split of the USSR renamed into Medical Universities or Academies). These facilities were linked to general fundamental sciences more loosely, compared to old faculties of classical Universities: The best scholars of natural and humanitarian science were still employed at classical universities. However, medical institutes were very effective in specialized applied professional training of many physicians (Balakhonov & Nezgovorova 2008; Zaichik & Churilov 2013).

The situation described above is not unique for Russia of Soviet period, with its rapid socio-economic development and neglecting of old traditions. The first medical school in USA (in Philadelphia) was established out of classical universities, as a specialized medical institution (1765) and became affiliated with the university after the revolution in 1791, almost 30 years later and

with serious friction and collisions between college and university medical professors (Fee 2015).

The system of "Medical Institutes" separated from classic universities was inherited by all post-Soviet states (although in national autonomies of former USSR Soviet system permitted to have classical universities with medical faculties – located in capital cities of republics). Since 90ies classical Universities in Russian-speaking countries started to open medical faculties again. Nevertheless, graduates of medical universities in Russia still (since 1931) do not prepare and defend graduation thesis, which is vice versa mandatory part of curriculum in a classical university.

However, the current system of medical education in Russia (and other post-USSR states) still does not prepare specialists designated for work at the interface between Medicine and natural sciences. By the way, in many universities of the world Pathobiology as the direction of training such personnel integrated in the educational programmes many years ago. This inevitably leads to a lag of Russian biomedical science in the number and quality of scientific elaborations for Medicine. The existing domestic programmes of training young physicists, chemists, biologists etc. do not provide them a sufficiently deep knowledge of medical subjects. On biological faculties, students do not study Pathophysiology, Anatomic Pathology, Pharmacology and clinical disciplines; they are not familiar with the medical thesaurus and not adopt bioethical corporate rules of medical professional behavior and clinical reasoning. All this facts are limiting the professional competence of a domestic biologist working in a medical facility or involved in medical research projects. At the same time, graduates who are training in medical specialties have not enough time in their curricula for getting profound knowledge of basic natural science, especially as regards to methods of modern Biomedicine. Hence, they cannot use it for the creation, development and application of modern scientific methods and technologies in health care practice as well as for the correct and heuristic formulation of tasks for the biomedical researchers (Churilov et al. 2014, Balakhonov & Churilov 2016). In 90ies state financing of science and education by Russian government of that period fell down to a catastrophically low level. Because of that, during these hard times medical education, science and health care system in Russia in general not only did not progress, but also even lost some advantages achieved in Soviet period (Churilov 2013).

### **How to teach physician fundamentally: role of systemic interdisciplinary approach**

Integration of natural and medical sciences in the training of medics must become the conceptual basis for the system of medical education. The creation of

integrative courses should be emphasized providing a transition from the disciplinary model of professional education to the system model.

The structure of knowledge is one of the most important parameters of professional education. The content of training should generally provide classic medical education combined with a deep fundamental (natural and humanitarian) teaching. This is achieved by optimization of the ratio and the content of the cycles of various disciplines, educational practice and internship, term papers in individual disciplines and in the discipline of specialization.

The actual implementation of the fundamentalization of medical education can occur when considering educational, scientific, methodological and organizational approaches to the educational process as a system, only in the indissoluble unity of the totality of the parties of such a multifaceted phenomenon as education. In this regard, an interdisciplinary approach to educating students is of particular value. An interdisciplinary approach provides an in-depth professionalization of the process of training and at the same time its fundamentalization. Along with a relatively detailed study of each academic discipline, it is necessary to restore meaningful bridges between them by identifying a common intermingled core of methodological approaches and representation of them in each discipline.

Fundamentalization of higher education determines one of the central tasks to be achieved by the student during his/her stay in the University, namely, the formation of a scientific outlook, critical reasoning and reflexive culture. The fundamentality of training provides undergraduate medical student with the generation of a natural science competence giving an opportunity to transfer to his/her practical and theoretical activity mastered knowledge, and do it consciously, with awareness and sufficient completeness. Without fundamental knowledge, medical specialist cannot act in an optimal way being in non-standard situations. Eventually, maybe, not in the first years of doctor's career, but via subsequent progress – this particular ability to act without ready schedules available would determine professional potential and limits of career growth for a person holding M.D. diploma.

### **Franco-German Pendulum and Russian Medical Education**

In the history of medical education, there are two major trends traced and corresponding two approaches to the training of physicians: The first is practice-oriented, where theoretical natural science training exists based on the principle of purely medical orientation knowledge. This approach dates back to the "Golden Age" of French medical school, first half of XIX century, epoch of René-Théophile-Hyacinthe

Laënnec (1781–1826), Armand Trousseau (1801–1867), and Guillaume Dupuytren (1777-1835), when it was elaborated and polished.

The second approach (we call it "German", because it is rooted into the educational practice of German universities of XVIII-XIX ages) focuses on the fundamentalization of medical education. Under this approach, theoretical knowledge in natural science has not only practical medical orientation, but is of independent value in the development of professional thinking of medical doctor (Balakhonov 2004a,b; Balakhonov & Nezgovorova 2008). Russians adopted both approaches in domestic higher school, and since XIXth century Franco-German pendulum and its fluctuations can be outlined in all reforms and innovations of medical education of our country, regardless of social and political changes through 200 years.

Currently in the Russian system of higher medical education, coexist both approaches to the training of a specialist. The first option is closer to the traditional system of training in medical institutes of the USSR. The main attention in the student training is being paid to develop skills of future doctors in major areas of their practical activity, like medical care, diagnosis, preventive and prophylactic work, patient's education (which in USSR was and to a large extent still is the responsibility of medical doctor, and not special certified medical educator, like in many other countries). The physicians, who received this type of medical education, should fully meet the needs of practical public health with their professional competence. The advantages of the existing medical schools are certain: They successfully cope with the objectives of the state educational standard in the training of graduates from different medical specialties. The second option is closer to the education provided by the medical faculties of the classical universities. It allows, if not completely remove, but at least to smooth out the emerging contradictions between the clinical reasoning and way of thinking adherent to scholar-experimentalist, putting closer existing traditional strictly disciplinary approaches to the higher medical education and the relevant today necessity of ensuring a holistic, systematic educational process development and the formation of the up-to-date physicians. There are classic universities with their traditions of systemic approach in teaching both scientific and humanitarian disciplines, that have new ways in the training of doctors of new generation, when along with profound learning of specific material, great attention is paid to formation of students' scientific worldview and systemic views on the ways to solve professional problems. For the graduates of the University's Medical faculty possession of the latest achievements of Clinical Medicine and skills of a doctor should be combined with fundamental training across the spectrum of natural sciences. It is important that

"University" approach does not exclude or deny the existence of specialized professional medical education, but enhances and extends it. Medical training itself should be at the same high level in both types of schools. Nevertheless, what concerns natural science training does not have to be identical. Natural science background of a physician in two types of medical educational institutions may be different, i.e. in classical universities – it should be deeper (Balakhonov 2004a).

Obviously, fundamentalization requires some alter-nativeness in the case of a particular institution, its mission and, equally important, its capacities. It is a wise combination of fundamental, general professional and special components of the higher medical education, that young person can receive in two types of the higher education institutions: In special medical universities or at the medical faculties of the classical universities. A graduate of the medical faculty of the University should be equally qualified for clinical and research activities, be able to combine them, as modern practical problems of healthcare are complex in nature and require creative, systematic, analytical approach for solving them.

### **Tsar's Will and Reality: Youngest Faculty of the Oldest University**

Saint Petersburg State University is the oldest classical university established in Russia, founded jointly with Academy of Sciences by the edict of Peter the Great (1672–1725) on 22 January 1724. An edict was prepared by Peter's surgeon in ordinary – Lavrentiy L. Blumentrost, 1692–1755. Although Tsar's written will clearly insisted to create among four initial faculties the medical one (Ustavy 1975), this suggestion came true much later. Why Peter I (known in history for his consistent iron innovative will) did not create in University the Medical Faculty? It did not occur because of both objective and subjective reasons. A role of occasion in history displayed in the following episode (Figure 3). By September 1725, all the Departments of newly established Academy and University found their Heads. Among them were several young scholars later on achieved world fame, like mathematician Leonard Euler (1707–1783) or physicist Daniel Bernoulli (1700–1782) – by the way, both initially have got in University tenured positions as... physiologists. Only one Professor's position was still without an employee: That was Head of the Department of Chemistry and *Practical Medicine*. Unlike relatively modest in means and mobile fundamental scholars, the experienced medical doctors in Europe were good established and not so inclined to change their profitable practice at home cities for adventures in remote and enigmatic northern country. L.L. Blumentrost finally invited for this position a friend of his Königsberg studentship, a Prussian doctor Michael Burger (1686–1726) from Libau, Kurland Duchess (that time ruled by Peter's niece Anna), a

specialist in Helminthology. Blumentrost wrote to his old friend, who, of course was not chemist, but medical practitioner: "If you are somewhat hampered by Chemistry, it can be discarded, since you are said to be entirely attached to practical medicine". The contract agreement with Burger was signed; one of his tasks was to start teaching Medicine at University. Burger arrived in St. Petersburg on March 13, 1726, and unfortunately worked at the Academy for only 4 months. July 22, 1726, returning from the celebration of L.L. Blumentrost's birthday, Michael Burger, in a violent alcoholic intoxication, fell out of the carriage and crashed to death (ISARAN 2017). The founder of University, capital city and Empire to that moment was already a year and a half in heaven, and no one in new government was consistent enough to continue the establishing of Medical Faculty. The objective reason of delay with Medical Faculty foundation was, of course, much more serious: Lack of demand from 8 to 20 students, studied at University in that period. Only free people could enter University: The children of peasants probably could be very enthusiastic medical students, but they were in serfdom and did not learn Greek and Latin at school, non-eligible to enter universities. The bourgeoisie just started to rise up in Russia of Peter's time. The nobles were eligible to enter University, but even the poorest of them did not consider a career of a medical doctor prestigious for their children. Another matter in their opinion was military or navy career: Combined with an officer's status even medical qualification considered prestigious enough. In XVIII-XIX ages medical doctors in Saint Petersburg were trained at Medical Surgical Schools (specialized institutions supplied staff for military and navy needs created by Peter I on 25 May 1706) In Moscow first of them functioned for some time since 1654, in capital city such schools functioned since 1735. Later since 1798, main center of medical education moved to Emperor's Medical Surgical Academy. It was medical school of top world level and at the same time one of the best schools of natural sciences in Europe. The medical education in this academy was based on university principle of solid natural science basis. To appreciate how advanced was this institution both in medical and fundamental sciences, one needs to know the following fact of its history. The Head of Chemistry Department of Medical Surgical Academy, an outstanding chemist, discoverer of aniline dyes and pioneer of studies in nitroglycerin explosive properties – Nikolay N. Zinin (1812–1880) was the first teacher of Chemistry and first scientific supervisor for young Alfred Nobel (1833–1896), who inherited from Zinin the trend of nitroglycerin studies, later brought to Nobel family fabulous money (Zelenin 2002; Zelenin et al. 2001). When Zinin's pupil founded Nobel Prize in Physiology and Medicine, he considered the possibility to grant the right to award it to the academic conference of the Military Medical Academy in Saint Petersburg, although finally decided for Karolinska Institutet.



**Figure 1.** Davidenkova L. “Let it be – University!” (Peter I signs the edict of establishment of the Saint Petersburg University), oil/canvas, 1994 (Corridor of “12 Collegi building”, St. Petersburg). Photo by A.A. Malkova

The retired ex-military physicians from this academy and civil medical graduates from other cities entirely satisfied the health care needs of civil population in Russian capital and its region for many years. Moreover, the town of Dörpat (at present Tartu) with its excellent old Medical Faculty dated back to 1632 was quite close by Russian measures (some 200 miles away from Saint Petersburg). For 14 years, this town even administratively belonged to Saint Petersburg province, and its University belonged to Saint Petersburg educational county through all XIX century. Many physicians graduated from there eagerly and successfully practiced in capital city (Churilov & Korovin 2016).

Russia in the end of XIX age was a country of advanced suffrage movement (first territory in the Europe, where women achieved full electoral rights was Great Duchess of Finland within Russian Empire as early as in 1906). Under the influence of democrats and suffragists in the end of XIX century, the Women’s Medical Institute was established in Saint Petersburg (1897) (Grekova & Golikov 2001). The above-mentioned Nobel family played some role in its development – they donated money for building and equipment of its

ophthalmological and surgical clinics, and Alfred Nobel’s niece Marta L. Nobel-Oleinkova (1881–1973) have graduated from this school with M.D. Diploma (Grekova & Golikov 2001; Zelenin et al. 2004). Therefore, ladies-physicians appeared in capital city and its region. In plus, in the beginning of XX century, an outstanding Russian psychoneurologist Vladimir M. Bekhterev (1857–1927) established in Saint Petersburg private Psychoneurological Institute (1906), initially a research facility which later (1911) started to train physicians (by the way, for first time in Russia male and female students studied there together).

In Russia “Zemstvo medicine” – a system of self-governed broadly available health care controlled by local deputies and all-Russia’s congresses of physicians – developed in late XIX – early XX centuries very rapidly, because it was generously financed by elected organs of local administration (so called “Zemstvos”). Tsar left at the disposal of the Zemstvos all local property tax, which was a huge sum of money. For example, in 1913 all Zemstvos of Russia taken together funded local health care with a money sufficient for construction de novo a one-way railroad of length equal

to distance between Moscow and Baykal Lake of Siberia. As a result, Russian medical demographic parameters improved in 50 years of Zemstvo's functioning radically, all medical aid and all prescribed drugs in Zemstvo medicine system to 1913 were free for peasants, and no rural inhabitant on the territory controlled by Zemstvos lived at a distance beyond 11 miles from the closest medical station! (Zaichik et al. 2013). A graduate of Saint Petersburg University and Dörpat Medical Faculty, well-known writer and Zemstvo physician of that period, Vikentiy V. Veresaev (1867–1945) witnessed that the salary of Zemstvo doctors was very good: Greater than an income of private practitioner in Berlin or Vienna (Veresaev 1961). Rapidly advancing medical aid system required for new civilian doctors: Many of them left big cities and even capital of Empire for employment in Zemstvo system. At the same time, in Military Medical Academy education started to adjust closer to the needs of army and navy, especially since the Great War was about to break out. Because of that, local parliament (Duma) of Saint Petersburg returned to the idea of Medical Faculty establishment in Emperor's Saint Petersburg University. To that moment, Saint Petersburg University with its more than 10 000 of students became the largest in the world, but still devoid of Medical Faculty, although its alumnus Ivan Pavlov and its associate professor Elie Metchnikoff already achieved Nobel Prizes in Medicine in 1904 and 1908 respectively. Metchnikoff was not medical doctor (he graduated from Khar'kov University, Faculty of Natural Sciences) and Pavlov added to his Saint Petersburg University diploma (Natural Sciences division, Faculty of Physics and Mathematics, 1875) also graduation cum laude from Military Medical Academy (1879). On 6 March 1913 Duma of Saint Petersburg by the initiative of a deputy A.G. Falbrok approved a decision to ask about opening of Medical Faculty within Saint Petersburg Emperor's University and even reserved piece of municipal land for that purpose (Zhurnal... 1913). However, the task was not as easy as it seemed to be. The project already agreed by Educational Ministry of Russia and approved by State Duma of Russia was rejected by academic council of Petrograd<sup>1</sup> University, which possessed with broad autonomy and was not obliged to follow will of ministries or parliaments.

In spite of positive attitude of several outstanding biologists, like Nobel Prize winner Ivan P. Pavlov and Nobel Prize nominee histologist Aleksandr S. Dogel' (1852–1922), the majority of academic council members voted against foundation of Medical Faculty. One of the greatest mathematicians of the world, Vladimir A.

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<sup>1</sup> After onset of Great War on 31 August 1914 on the top of anti-German campaign, Tsar renamed city of Saint Petersburg into Svyato-Petrograd.

Steklov (1863–1926) argued categorically in contradiction of this idea: "The inclusion in the cycle taught at the University the subjects of narrowly practical nature, the inclusion in the University of a large number of professors-clinicians, i.e., representatives of purely practical professional knowledge, etc. – all this can not endure but break the scientific life and spirit of the university". Many scholars interpreted the University as an "ivory tower" designated exclusively for pure fundamental science and principally abducted from any applied and non-academic matters. They did not see scientists in medical doctors, because of obvious differences between scientific and clinical ways of reasoning. As a kind of compromise, Russian government created in 1916 medical groups in university and its filial established in provincial city of Perm', but with written note that their students will be transferred to other medical faculties after 4 terms of pre-medical training (Rostovtsev & Sidortchuk 2015). One of obvious losses of University was a leakage of talented young people seeking for medical career. A bright example was Lev A. Zilber (1894–1966). A talented young man from provincial city of Pskov, located in neighborhood, entered Saint Petersburg University, expecting that Faculty of Physics and Mathematics (already having Natural Sciences' division) soon will open medical division, as it was proposed. Nevertheless, after fail of Medical Faculty project, Zilber had to transfer from Petrograd to Medical Faculty of Moscow University (1915). Later he achieved world fame as an outstanding immunologist, virologist and onco-pathophysiological, author of viral-genetic theory of carcinogenesis (Kiselev & Levina 2004).

After anti-monarchist revolution in February 1917 University kept its autonomy and rights: Provisional government of Russian Republic still could not dictate play rules to academics. In May 1917 government again proposed to organize in Petrograd University medical teaching. The heads of existing civil medical schools: V.M. Bekhterev from Psychoneurological Institute and B.V. Verkhovskiy (from Women's Medical Institute, which started from 1917 enroll the male students also) – argued against the establishment of new medical school, insisting that their institutions can increase annual admittance and cover all needs of the city and region in physicians. V.M. Steklov and other opponents of medical teaching within Petrograd University did not change their view, even in spite of growing social need in medical teaching, dictated by poor epidemic situation caused by disasters of war and revolutions. Finally, it was decided to organize pre-medical part of curriculum in Petrograd University and all clinical teaching – out of it, at other institutions. This strange decision made all project nonsensical (Rostovtsev & Sidortchuk 2015). Soviet government preferred another way, described above: With creation a net of medical institutions out of classical universities – and never returned to project of

medical teaching in Leningrad State University (Between 26 January 1924 and 6 September 1991 Saint Petersburg bore the name Leningrad, after graduate of Saint Petersburg University, founder of the USSR Vladimir I. Lenin (1871–1924). In 1932 first in the world, graduate Paediatric Medical Institute was established in Leningrad based on former Research Institute of Maternity and Childhood (Grekova & Golikov 2001). Several outstanding natural scientists from University, including a Nobel Prize nominee pathologist, radiologist and biochemist Efim S. London (1869–1938) came to teach paediatricians there, but Leningrad University did not acquire Medical Faculty neither from Russian Empire, nor from Soviet State.

### Medical Faculty in Saint Petersburg University: New Type of Medical School

The city to 1995 already had in function four state medical schools and one private, as well as Academy of Veterinary Medicine and Chemical Pharmaceutical Academy, all of them very popular among applicants and producing thousands of medical specialists annually.

For establishment of the Medical Faculty in St. Petersburg State University in 1995 (by initiative on an outstanding physiologist academician Yuri V. Natchin), one of the main reasons was that in St. Petersburg there are many research institutes of medical and biological

profiles pertaining the Russian Academy of Sciences, the Russian Academy of Medical Sciences, and Ministry of Health. With their participation, it was possible to prepare highly skilled physicians. Moreover, these institutions for their own function in the end of XX century required fundamentally new type of specialists, able to quickly join in tackling the solutions of research tasks that are facing both clinicians and scientists (Natchin 2001, 2004). Usage a leading research facilities of Saint Petersburg as the basic institutions for training and research, and for studying clinical disciplines, allows the Medical Faculty really strive for the implementation of integration of academic science and higher medical school. To achieve this task at the Medical Faculty, changes were made not only to the education process, but also to the organization of students' activity: The increase for self-studies, productive knowledge-based teaching technologies, integration of educational and research work, etc. Integrated curriculum has in addition to the required state standard level of knowledge in the specialty "General Medicine", also considerable part of project and research competence, skills of research work, wide variety of elective and facultative courses. The curriculum is designed such way, that students not only receive a classic medical education, but also individually study the new achievements in the field of natural sciences, methodology and skills of scientific work during all six years of graduate education (Table 1).

**Table 1.** Distribution of credits in M.D. curriculum of class, enrolled in 2011 in 2016-17 academic year at Medical Faculty of Saint Petersburg State University\*

Group of disciplines (number of credits indicated for selected subjects), clinical subjects with basic biomedical teaching embedded <i>are emphasized</i>	Number of credits	Including Practical training & Work experience
<b>HUMANITIES</b>	33	-
English (18.5 credits), Latin (3), History (2), History of Medicine (2), Law (1), Economics (1), Philosophy (2.5), Bioethics (1) etc.		
<b>NATURAL AND BASIC SCIENCES</b>	90	4.5
Biology (9.5), Chemistry (11), Physics (3), Biochemistry (7), Gross Anatomy (11), Anatomic Pathology (7.5), Normal Physiology (8), Pathophysiology (7), Endocrine & Metabolic Pathology (2), General, Molecular and Medical Genetics (5), Cytology & Histology (6), Microbiology, Virology & Immunology (7), General Immunology (2) etc.		
<b>CLINICAL SCIENCES</b>	222	25.5
General & Clinical Pharmacology (9.5), Clinical Pathology (2), Autopsy & Biopsy Course (1), General, Academic & Hospital Courses of Surgery (47), Introductory, Academic and Hospital Courses of Internal Medicine (41.5), Paediatrics (10), Obstetrics, Gynecology & Reproductology (15.5), Infectious Diseases (7.5), Neurology & Neurosurgery (5), Psychiatry, Medical Psychology & Narcology (5), General & Clinical Oncology (5), Ophthalmology (4), ENT (4), Forensic Medicine (3), Dermatovenerology (3), Epidemiology (3) and Hygiene & Preventive Medicine (5), Subordinatorship in graduate year (21.5), various minor clinical disciplines, etc.		
Total	345	30
Graduation thesis preparation & defense	17	
<b>Grand total (credits/hours)</b>	<b>362/11834</b>	

\*Term papers totally require 6 credits. Self-studies in every subject occupy 1/3 of time and 2/3 of time is designated for contact hours

The students spend in University 12 terms. The last year mainly is dedicated to sub-ordinatorship (supervised staging of students in internal, surgical, obstetric/gynecological and paediatric clinics) as well as to preparation and defense of graduation paper. Humanities mostly taught in 1<sup>st</sup> year, although English teaching spreads through all duration of curriculum (much longer than in specialized medical schools). The natural and basic medical sciences are taught mostly within 1<sup>st</sup> to 5<sup>th</sup> terms, although teaching of Pathology (both Pathophysiology and Anatomic Pathology) is spread through the whole duration of curriculum due to admixed clinical and biomedical courses (for example: Endocrine and Metabolic Pathology, Clinical Pathology, General and Clinical Oncology, Clinical Pharmacology etc); and by means of the electives (like Actual Problems of Clinical Anatomic Pathology, Systemic Pathology of Connective Tissue, Clinical Anatomy, etc). To realize such a mode of instruction we broadly apply interdisciplinary teaching: Many courses are taught by specialists from different basic and clinical departments together. For example, in teaching of Systemic Pathology of Connective Tissue the lecturers from 6 departments (having 7 various specialties) take part.

Yet, it is not easy to combine competencies of medical doctor and scholar in one person or within the same curriculum. One seeks for scientific truth, another one for benefit to patient. One is strictly limited in time while performing professional actions, another one always has long perspective of endless research. One can split the object of research for reveal of the true, another one has to spare and protect it, because the subject of his search is alive person. One is trying to avoid mistakes, for another one mistakes are normal required elements of experimental research (Churilov et al. 2014). How to combine an endeavor for new not yet entirely proven knowledge typical for a scholar and evidence-based approved schemes used by clinician?

Here is the opinion of an outstanding embryologist from Saint Petersburg University, Boris P. Tokin (1900–1984), who in private conversations with one of the authors of this article (AVB) has repeatedly expressed the idea that delivering lecture course a teacher should primarily offer listeners a well-established, generally accepted knowledge, without the full development of which it is impossible to advance. In addition, the controversial issues in these courses are only touched. These lectures should “lag one day”, according to B. P. Tokin, “from modern state of the problem”. In other words, the basic courses create the foundation for a full and comprehensive development of a scientific discipline, for the formation a system of special knowledge in a young man. Here priority should be given to the best lecturers bright orators and propagandists of scientific achievements. The up-to-date state of a particular branch of science and its perspectives for

tomorrow should be studied by students during elective courses, where a teacher has a greater freedom in the choice of subjects of lectures, presentation of controversial issues, and different approaches to its solution, to openly defense his views and preferences. Moreover, here the priority should be given not as much to the orator, as to the researcher.

Of course, the idea of a "one day lag" one should not interpret too literally; the crux of the matter here is not in the traditional distinction between basic courses and special courses in extent and significance of the given information, but in didactic approaches to their content. Special courses or elective courses allow greater freedom of choice, while the basic course of lectures should be more academic, rigorous and systematic. Conceptual and factual knowledge are equally important, although didactically they may vary. Note, however, that classic universities have more features compared to the specialized universities in the implementation of these approaches. In classical university during pre-medical course of first 3 terms students study Physics at Physical Faculty, Chemistry – at Chemical one, languages – at Philological Faculty, humanities – at other profile faculties of classic university (Philosophical, Sociological, Psychological, Historical etc). Consequently, it is a classical university that has the most favorable conditions and opportunities for putting into practice the ideas of fundamentalization of higher medical education. Several authors of this paper taught both in specialized medical and in classical universities, and our experience shows that in classical university majority of students come to the senior years of curriculum with better knowledge of basic disciplines, compared to those studying at autonomous medical schools. At the same time, our experience showed that multi-Faculty schedule of studies might pose also certain problems for training of a physician. In specialized medical schools all subjects, including non-medical ones, from the very beginning of curriculum bear strong impact of medical profile. It is not always the case in classical university, requiring additional efforts in order to intermingle and admix the medical and general tasks of instruction. In fact, first year students of Saint Petersburg University obtain at Medical Faculty only those disciplines, which are absent in scope of other faculties: Human Anatomy and Patient Care. As a result, in specialized medical schools students can easier and earlier adopt a medical ethical code of conduct, they get more profiled courses of Foreign Language, Histology and other subjects taught at the classical university outside the Medical Faculty. But this is quite a solvable problem: For example after few years of Medical Faculty functioning we created for our students specialized guide with audio-CD “English for Medical Students” – in order to achieve proper profiling in language teaching (Churilov et al. 2012).

Formation a persistent cognitive necessity in students is inseparably linked to self-studies and research activities that open up broad perspectives for the development of this need. Therefore, in our practice in several lecture courses we apply educational technology of problem-based learning, the essence of which is the organization of independent cognitive activity of students: Knowledge is acquired in the process of resolving a problem situation, a special cognitive task. From an educational point of view, the students' involvement in research work at its essence can be considered as a branched project-oriented instruction, a learning system in its kind. In course of Clinical Pathology as well as in several electives of pathophysiological content instead of common lectures we deliver clinical-pathophysiological workouts with demonstration of real patients and/or case histories and participation of both clinician and pathologist.

### **Role of Term Papers in Joint Learning/research**

Students of Medical Faculty of Saint Petersburg University get the first skills of research, scientific analysis and the experience of direct participation in scientific work when writing a scientific (usually biological) term papers in first and second semesters. Preparation and implementation of the course paper is an obligatory part of the curriculum. Writing of such papers can be considered as the students' initial steps for inclusion in the research activity, that contributes to the formation of professional competence, i.e. the ability and willingness to apply the systemic knowledge, skills and personal qualities in the field of fundamental sciences in the further study of medical, biological and professional disciplines.

The term papers in first and second semesters represent the reviews of literature by their genre. The choice of the term paper topic in Biology is very wide; students determine it on their own, on the basis of their interests, preferences and knowledge acquired in high school. Term paper may relate to any section of Biology science – laws of biological evolution (or evolutionary development of body systems), the structure and functioning of body systems, principles of preservation and transformation of biological information, laws of heredity, variability, methods of transmission of genetic information, patterns of mutational processes, modern opportunities in detection of genetic predisposition to human diseases, ecological and parasitological studies of natural communities and their inhabitants, individual development of organisms or organ systems, the relationship of organisms in nature, and much more.

It is important that the topic of the term paper must not have a *purely* medical focus, but it is desirable to reflect the relationship of natural science knowledge with medical problems. Thus, term paper on the human

circulatory system needs to cover a broader topic – e.g., "Morpho-evolutionary overview of the circulatory and lymphatic systems of animals", the topic of the paper about human lungs – "Physical basis of gas exchange in the respiratory systems in vertebrates and invertebrates", the topic of the healing wounds in humans - "Influence of nervous (or endocrine, immune...) system on regeneration processes", etc. (Balakhonov 2004b; Erofeev et al. 2010).

Because of this approach, complex scientific problems become objects of the review that requires interdisciplinary integration, transfer, and synthesis of knowledge from different sciences and sources. That is the interdisciplinary term papers of first year students integrate training and research activities as a condition of fundamentalization of the educational process.

Overcoming challenges related to the execution of the review, stimulates learning at the systemic level, learning structure of knowledge, as well as increasing motivation in studying purely professional disciplines. Therefore, the acquisition of skills of work with literature or other information sources, including the Internet, identifying specific research tasks, assessments of the modern state of the studied question provides to the student substantial help in the future, in educational and research activities.

A distinctive feature of the term paper in Biology is that student must not only write the work himself, but also he/she publicly presents it (in front of his classmates): Creates a presentation, within 8-10 minutes verbally summarizes the main contents of the work, and answers the questions. Herewith comes learning the rules of scientific discussion skills, expression their thoughts and their defense, the ability to formulate questions and answer them, to respect the opponent (Balakhonov 2006a,b). The culture of disagreement, which is mandatory element of academic ethics, is implanted into learning minds. According to O. B. Shulepova (1997), respect for the opinions of others demonstrates willingness to dialogue, so necessary at the present time, instills tolerance for the views of an opponent, reveals the understanding of the ambiguous road to truth. "No one is in possession of ultimate truth", – this sentence (Soros 1997) addressed to understanding of social and economic processes can be applied broader – to all kinds of scientific research and to biological defensive function of the organism itself, which is also imperfect. The specific learning environment, emerging at the Medical Faculty, affects the choice of the rules of communication and ways of behavior in the young generation of a particular social group. This choice determines the manner of communication, behavioral and cognitive style, which in the future will appear and will persist in interpersonal and business contacts of an adult person.



**Figure 2.** Medical students and teachers of Saint Petersburg State University during summer field practice in Biology & Ecology on the isles of White Sea

First year is ended with summer field practice in Biology and Ecology. The medical students go with their scientific supervisors on the expedition, to make field studies in Zoology, Botany and Ecology. They travel to Biological research stations of Saint Petersburg State University, one of them is located on the shore of Finnish bay near Peterhof, another one – on the island in White Sea, near the Arctic Circle (Balakhonov 2006b). Here they take part in practical studies and learn the essentials of scientific work in research team (Figure 2).

Starting from the second year, medical students prepare two of three term papers during each academic year, and the older is the student, the closer these works stand to the actual medical problems. On the second year, there are three such works: on Normal Physiology, Biochemistry and Microbiology. For example, one of the main objectives of the "Normal Physiology" course is the study of the mechanisms of the body systems functioning. Understanding of the mechanisms of functioning of systems and organism in general requires extensive and strong knowledge of related disciplines: Mathematics, Physics, Chemistry, Biology, Biochemistry, Histology, Anatomy, etc. Writing a coursework

in Physiology, students must demonstrate an understanding of the multiple levels of regulation of physiological functions (Erofeev 2010). Student analyzes some physiological phenomenon, trying to display a comprehension of its multi-level nature, with local and systemic levels of regulation (from the submolecular to the organismic ones) for a given process or organ system. If, for example, selected topic is related to the mechanism of action of thyroid hormones, it is necessary to demonstrate knowledge of cellular and molecular mechanisms of their action (reception, post-receptor transmission, genetic and epigenetic effects on metabolism or function of individual organelles). The description the phenomena that occur under the influence of these hormones in the particular organ is also needed. Working like this student should undertake an analysis of systemic mechanisms for maintaining hormone effects at a certain level (the afferent stimuli, hierarchy of the local vs systemic regulatory relations, negative and positive feedbacks; substances modulating this function; at what structures the regulation targets etc.). Finally, he/she needs to comprehend how a change in this system affects the functional state of other organs

or organ systems. This term paper may still be theoretical, but active and adherent to research students are provided enough opportunities to perform original practical research – the Department of Physiology has full set of special scientific medical equipment and sensors for registration of functional data from all organs and systems. The students perform on themselves non-invasive studies of human organism functions, working in small research groups. They report the results in the end of an academic year, during special research conference which is at the same time a procedure of course paper defense. Which is most important, the methods of these physiologic studies are the same applied in functional diagnosis in practical health care. Due to this, the students not only train in methodology of scientific research and data processing, but also take first lessons of functional and instrumental diagnosis, required later in clinical studies of senior years.

The similar rules exist for term papers in Biochemistry and Microbiology.

The next phase of training is the study of Pathophysiology. This science is a key part of a number of professional competences: Such as development of a systematic approach to the analysis of medical information; the ability to carry out pathophysiological analysis of clinical symptoms and syndromes, to justify pathogenetically based principles of diagnosis, treatment, rehabilitation and disease prevention; the ability to make a diagnosis based on the results of laboratory data in accordance with the natural history of disease etc. During the diagnostic and treatment process, medical doctor creates a conceptual model of a particular disease that should meet all information collected about the patient and coincide with typical disease models learned during training. Though this is a pathophysiological task, the one who is solving it is a clinician.

Many functional and laboratory tests are actually clinical and pathophysiological experiments performed in the medical diagnostic process for the benefit of the patient by the practitioner. Such experiments belong to pathophysiological methodology of knowledge, but medical doctor, not scientist, performs them in the clinic, not in the laboratory or vivarium. Therefore, the medical profession requires some pathophysiological competencies. No wonder, an outstanding Russian pathophysiological Vladimir V. Podvysotsky (1857–1913), graduate of classical St. Vladimir University at Kiev, on the eve of modern Medicine said: "Every particularistic pathologist, that is, every general practitioner while standing by the patient's bed, must necessarily be to some extent the general pathologist, unless he wishes to be truly useful to the patient, if he wants not to cure the disease according to memorized recipes, but treat each patient individually... That extraordinary success in medical practice, which could get in the older days, after 20–30 years of work, capable and brilliant doctor,

who never studied General Pathology as an individual science; such success may now have almost any average medical doctor, if only he'd been sensible and hardworking as a student, if he came into the clinic, truly assimilated the main foundations of modern General Pathology" (Podvysotsky 1905).

The main form of instruction in Pathophysiology is the interactive learning based on the integration of learners with the area of mastering experience, with the teacher and with each other during planning, conducting, data registration and discussion of educational experiments. Educational experiments (from 1 to 4 in every laboratory class) are scheduled in the plan of laboratory classes in Pathophysiology. During the experiment, we combine a work of the student under the supervision of a teacher and a self-work of students in small research groups.

In didactic literature (at least, domestic one) somehow was fixed a simplified understanding of interactivity only as an interaction with a computer program in the course of training. Meanwhile, one or other, even fashionable and new learning tool, does not define interactivity. Interactivity involves the interaction of three systems, each one with its own independent programme of behavior – *a learner, a teacher and an object of educational activity* that is not necessarily virtual, and in medical education is often real (biological preparation, pathology pot, histological slide, dissection object, experimental animal, patient during interview and examination). Interactive learning means it based on the interaction of learners with the area of the mastering experience, with the teacher, and with each other. Computer simulation of the object – is a matter of lower interactivity forms, as the virtual model as a rule has few degrees of freedom and a smaller element of unpredictability of its behavior, compared to the real object. The experimental animals in educational experiments, the patients during clinical investigation – these are systems with infinitely large number of degrees of freedom and variability of their own behavior programs than any computer cartoon or movie.

It is here, when the teacher and students work together in a situation of incomplete predictability of events, the highest form of interactive learning starts. In particular, in medical education – teaching experiments, clinical and pathophysiological analyses make the important part of it (Churilov & Utekhin 2017).

Another important aspect of the Pathophysiology learning – an active and interactive self-work of students on term papers, recommended topics and rules of which are explained to students at the first laboratory class by appropriate sections of the "Workshop" – a book describing main aspects of laboratory studies. During the Pathology course students under the guidance of the teacher choose, prepare and present the term papers on Pathophysiology and on Anatomic

Pathology. Term paper on the Pathophysiology – is a literature review on the actual issue of Pathology performed personally by student that deals with etiology, pathogenesis, modeling of diseases and/or pathological processes, history of Pathophysiology. The work may contain materials of student's personal original research in Pathophysiology, made in the Student Scientific Society (SSS), materials of teaching experiments performed in the classroom, investigation of statistical, clinical, functional and metabolic data from medical records and other clinical documents, experimental, descriptive or clinical data supplied for analysis by the scientific supervisor of the student.

Term paper on the Pathophysiology is written and presented in the 4<sup>th</sup> or 5<sup>th</sup> semester. Presentation takes place during the last laboratory class of the term in the form of a scientific-educational conference of the student groups with peer reviewers—students of the same group. The best term papers are submitted to academic journals for publishing. The ongoing interaction of students and teacher on issues of term papers can be carried out in extracurricular time, using the Blackboard learning platform, or during the SSS meetings, in the dialogue through the social network, via the web pages of the Pathology Department, teacher or SSS.

With all the variety of disciplines and topics of term papers written, they are all united in the ultimate goal. Clinical term papers are primarily aimed at the formation of the main "tool" in physician's practical activity – the clinical reasoning.

These term papers are produced on 4<sup>th</sup> and 5<sup>th</sup> years. They are traditionally created in the form of training case histories (or birth histories – in the study of Obstetrics), which help students acquire core professional competencies: Ability and willingness to establish a systematic approach to the analysis of medical data based on the search of solutions using the theoretical knowledge and practical skills to improve professional activities.

Term paper allows achieving the basic aim of the clinical disciplines – the acquisition of practical skills of the contemporary physician:

- the ability to recognize the most common diseases;
- the ability to measure activity of the pathological process, evaluate its form and stage in accordance with classifications accepted by medical community, notice and analyze the presence and severity of complications;
- the ability to formulate a diagnosis in accordance with accepted classifications of diseases;
- the ability to develop a plan of drug and non-drug treatment of the patient in accordance with diagnosis, taking into account indications and contraindications for surgical intervention and its urgency;

- the ability to develop a set of measures of primary and secondary prophylaxis of the disease and its complications, to assess the prognosis for life and for disability;
- the ability to use basic principles of medical ethics and deontology while working with the patient, his relatives, his individual data and medical staff.

For implementation of the term paper the hours of students' self studies under the guidance of the teacher increased in the curriculum. Each student is given a patient with a certain disease for observation (curation), during the study of which the coursework (case history) should be written. Thus, students' familiarity with various aspects of the etiology, pathogenesis, clinical manifestations and treatment of major diseases occurs directly via concrete case of an individual patient, with the active participation of student. Students write their teaching case histories according to the basic rules of case history writing adopted in appropriate clinics and with special features for every nosological form.

The student at the bedside of a supervised patient provides an initial diagnostic search, including interview taking and examination of the patient by systems and organs (visual examination, palpation, percussion, auscultation), and then proceeds to the formulation of a preliminary diagnosis. This is one of the most important sections of the term paper, as there students make advanced practical steps in the development of the skills of clinical reasoning, which involves careful clinical investigative work with the patient and the study of a considerable number of references.

The next stage of diagnostic search is a plan of laboratory and instrumental tests for a concrete case. Author of a case history required to justify the diagnostic value and the necessity for proposed additional methods of investigation, clearly understanding the purpose and their importance in solving the key questions of diagnosis of the disease, in determination of the stage and phase of pathological process and in evaluation of the development of possible complications.

The result of this work is the differential diagnosis – a comparison of patient data with disease, the clinical representation of which is similar to the studied one. The student must obtain the contemporary ideas about the causes, pathogenesis, and diagnostic criteria of diseases in the study of modern scientific literature. Fully carried out differential diagnosis will allow students to formulate the final clinical diagnosis and create an adequate treatment plan for the patient care.

In the process of diagnostic search, students typically face a range of difficulties. A significant difficulty is to obtain sufficient information for diagnosis because the students, on the one hand, have insufficient skills of work with patients and, on the other – getting the facts, they sometimes cannot correctly interpret them and

properly use for diagnosis. One of the main tasks of the teacher is a control of each stage of student's work on the case history and timely correction of the research work of the student.

Thus, the students' term papers in the clinical departments of St. Petersburg State University, focused on future practical activity, regardless of which area of Clinical Medicine a graduate eventually will choose.

### **Graduation Thesis as a Final Step: Not Only Clinics**

The final stage of training at the Medical Faculty is a graduation thesis publicly presented in the end of the 6<sup>th</sup> year. Curriculum reserves 17 credits for preparation and defense of graduation paper. Defense occurs after conclusive exams and precedes conferring upon the M.D. Diploma. This is a main difference with instruction in specialized medical universities of Russia, where graduation thesis is not required for obtaining M.D. Diploma. Students present their experimental, epidemiological or clinical research in a particular field of Medicine, which was carried out during the years of training in medical school. Any department, including that of basic sciences can supervise graduation paper. It means that a graduate in order to obtain M.D. Diploma in General Medicine and enjoy with clinical qualification can submit and defend graduation thesis not only in clinical disciplines, but also in Physiology, Pathophysiology, Anatomic Pathology, Human Anatomy or another basic discipline. All graduates of the Medical Faculty achieve M.D. Diploma in General Medicine. They are immediately eligible for postgraduate fellowship in basic sciences or for clinical residencies and postgraduate specialization (in home school or other institutions). To practice medicine in health care system a graduate goes through so-called primary attestation, performed by special board from representatives of universities and local medical community.

Stepwise involvement in broader options for research work with every next year of medical education creates a basis for the formation of the researcher's competence and for the realization of the concept of the Medical Faculty, which is training of the new type of physicians – practitioners-researchers.

This system has a significant impact on personal and professional development of the student, facilitates the transformation from his position as a subject of educational activities into the position as a subject of professional activity. The indicators of this transformation are the following:

- the ability to use scientific and medical knowledge in their relationship to the achievement of practical and theoretical professional tasks;
- the development of communicative capabilities, cooperation with teachers, experts from other organi-

zations, patients, and the formation of professional communicative culture of the graduate;

- the development of analytical and research skills (identify problems, their causes, collect and analyze information, make observations, propose a hypothesis, choose the most productive methods, carry out experiments, generalize the results of the analysis, observations, make conclusions);
- the development of a systemic professional reasoning, personal and professional competencies, achieving professionalism, and professional maturity;
- the sustainability of motivation in the chosen medical profession, its spiritual and moral values.

Successful completion of the work and ensuring a qualified guidance depend on embedding of student's graduation paper into research projects, developed by a department, which is guiding student's work. Thanks to this, the students are directly immersed in the actual research process, not engaged in the creation of some abstract ersatz model of "student's science", which is often a substitute of real research. Evaluation criteria for graduation theses are of some special interest. First, the evaluation is based on criteria of completeness of the topic of thesis, how the topic is matching to its content. The stylistic of thesis presentation, presence and quality of original research material, scientific and practical value of the findings obtained in the thesis, the quality of the study design, consistency of conclusions made – all that influence the collegial decision of the State Attestation Commission. The members of commission take into account evaluations and recommendations of the supervisor and independent reviewers of the thesis. They evaluate presence and quality of illustrative material, knowledge of modern world literature related to topic of thesis, ability of an author to lead in academic debates, etc. The commission obligatory includes the representatives of health care institutions and medical research institutions independent from University and unrelated to its staff; moreover, for objectiveness of decisions, the teachers of University should always be in minority among members of commission and its chairperson as a rule is not a University employee.

A thesis without properly processed original data cannot pretend for excellent grade. The degree "cum laude" is available only for those students who during six years of curriculum not only visited lectures and read the right books, but worked personally and productively in basic and/or clinical research projects. An important advantage in the evaluation of the qualification work is the availability of publications on the research topic.

The term papers and graduate thesis included in the curriculum of the Medical Faculty of St. Petersburg State University as the compulsory elements of self-studies through research work. Optional or elective elements of such studies are activities within SSS, which exists in every department.



**Figure 3.** Russo-Croatian Seminar in Clinical Pathophysiology within XX International Biomedical Conference of Young Researchers “Fundamental Science and Clinical Medicine – Homo and Health”, 22 April 2017

The key traditional event of corporative culture at Medical Faculty of Saint Petersburg University and the most essential element of the intermingled research and educational process is the Annual biomedical conference of young researchers "Fundamental Science and Clinical Medicine. Homo and Health". It virtually unites all trainees and teachers – from high school pupils preparing to enter the University, to most distinguished academicians. It was organized for the first time in 1998 by the initiative of the founder of Medical Faculty, academician Y. V. Natochin. First event was of small scope: About 40 young researchers from Saint Petersburg (23 of them – first students of recently established Medical Faculty) presented and discussed their research data. The idea was supported by Russian Academy of Science, clinical and research institutions, scientific and medical professional societies of the city.

With every next year, the popularity and scope of the conference increased. From the second year the Conference has acquired the status of all-Russia's one, and since 2012 – became international; in 2017 XXth conference attracted about 800 young researchers from 80 cities of Russia and 17 other countries with oral and poster presentations in sections of Biomedicine or Clinical Medicine. The abstracts of conference are published in periodical annual selection book included in Russian Index of Scientific Citation database. The conference is a platform for approbation of course papers and graduation theses; it is also very important event for the professional orientation of applicants.

Every year leading scholars of the world open this conference with their lectures for participants. Among

its participants, one can find senior school pupils, students, postgraduate fellows, clinical residents, young research and clinical specialists from universities, research institutions and hospitals, etc. Many of those who participated in first conferences as students and even high school pupils during elapsed 20 years of its tradition progressed up to the ranks of young associate professors and professors; one of the first participants is already young member of Russian Academy of Sciences. During last two years students from Croatia took part in this event (Figure 3).

### Conclusion

Thus, in our opinion, the path of integration of science and practice in medical education requires the acquisition of new competencies by the graduates – both medical doctors and biologists. This can be achieved by creating a new direction of training for biomedical staff, which is Pathobiology or Translational Medicine. This is possible for University having its own multi-profile teaching hospital and resource center of the clinical research with the legal position of an outpatient medical facility. Important additional areas of work in this project are the establishment of integration, interdisciplinary ways of learning, as well as measures to strengthen academic mobility and the communicative freedom of teachers and students. At the Medical Faculty of St. Petersburg State University, which originally appeared with great organizational and ideological onward of stereotypes existed at that time, considerable preparatory work in this direction was done for 22 years of its development.

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**Contribution of individual authors:**

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Mikhail V. Erman - text of parts 7-9;  
Aleksandr N. Shishkin - text of part 7-8;  
Lyudmila A. Slepkyh - text of parts 7-8, table 1;  
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Correspondence:

Leonid P. Churilov, MD, PhD

Department of Pathology, Faculty of Medicine, St. Petersburg State University  
of. 111, bld. 8A, 21st line V.O., Saint Petersburg, 199106, Russia

E-mail: elpach@mail.ru