Academia Europaea
Cardiff Knowledge Hub

INTERVIEW SERIES

Life as a Ukrainian scientist: an interview with Yaroslav Shuba MAE

WE STAND WITH UKRAINE

In this important interview, newly-elected MAE Yaroslav Shuba charts his life as a scientist, from the Soviet era to independent Ukraine.

Professor Yaroslav Shuba, is a physiologist from Ukraine working in the Bogomoletz Institute of Physiology in the National Academy of Sciences of Ukraine (NASU) in Kyiv. He is Head of the Department of Neuromuscular Physiology.

Professor Shuba was elected as a real member of the National Academy of Sciences of Ukraine in 2021 and to the Academia Europaea in 2022. He has been listed as a noteworthy physiologist, director by Marquis Who's Who.

In 2003, Professor Shuba was awarded the State Prize of Ukraine in the field of Sciences and Technologies and in 2010, he received an Honour of excellence from the Ukrainian Parliament. In 2013, he won the National Academy of Sciences of Ukraine's 'P.G. Kostyuk Prize' in Physiology, Biophysics and Neurophysiology.

How did you start your scientific career? Was there anybody who influenced you the most?

"As for every young person graduating from high school, I had to make a choice about what to do in life. For me, it was at the beginning of 1970s. In the Soviet Union (as it was then), the debate on *The Two Cultures* – the sciences and the humanities – was at its height. It was initiated by the British scientist and novelist Charles Percy Snow in 1959. In the Soviet Union, it took the form of a discussion between "physicists" and "lyricists" on various aspects around the importance of each to the development of society. For me, this discussion had real meaning, as I had some innate talent for painting, and in my teens had attended various art studios. However, the impressive achievements and practicality of the natural sciences eventually put the "physicists" at the top of my list, and after some hesitation I decided to become one of them. So, I entered the radio physics department of Kyiv Shevchenko National University.

The progress of nuclear and plasma physics during the 1960s-70s gave the impression that controlled thermonuclear fusion, as a limitless and safe source of energy, was within reach. After graduation in 1977, I became a technician at the Department of Gas Electronics at the Institute of Physics of the National Academy of Sciences of Ukraine (NASU, back then the Academy of Sciences of the Ukrainian SSR). It specialised in using "ionic guns" and ion beams to study the interaction of high energy ions with matter, with the ultimate goal of heating up plasma for thermonuclear fusion. Experimental setups were gigantic there - powerful pumps making a vacuum in long metal tubes, filling up those tubes with various vaporised matter, ionic guns shooting ion beams through this matter, detectors for the end results, and so on. And all this machinery needed megavolts and megawatts of electric energy to operate. So, experiments had to be planned in advance and they had to be conducted by a whole group of people - a single person could not operate the setup alone. And that was what I did not like, since in such a situation you cannot be the master of your time and do experiments whenever you like. Nevertheless, I always eagerly participated in the preparation and conduct of experiments, and became a co-author of my first three scientific papers published in USSR physics journals.

There was also another good experience. These gigantic setups I worked on needed a lot of custom-made parts and components, which were manufactured onsite in a specialised machine shop. By having to oversee this production, I learned how to operate different metalworking machines and how to use them to build various things. This appeared to be very useful in life, as I knew how to make basically everything myself – without having to ask anybody.

Both my parents were biologists. Although they never interfered with my work as a plasma physicist, they always tried to develop my interest in biology, particularly biophysics. I remember how my father was always initiating conversations about nerve electrical impulse propagation, underlying transmembrane ions movements and Hodgkin-Huxley theory, and he encouraged me to read literature about them. At the turn of the 1970s and 80s these were very hot topics, and, luckily, Kyiv became a centre of related research not only in the USSR, but internationally. This was because at the Bogomoletz Institute of Physiology (BIPh), NASU (under the leadership of its long-term director, Prof. Platon Kosyuk (Figure 1)), developed the new technology dubbed "intracellular dialysis" (there was also a variant called "intracellular perfusion") (Figures 1 &2).

This technology enabled the measurement of electrical signals (transmembrane currents and potentials) from isolated cells under conditions when the composition of not only extracellular, but also intracellular milieu could be controlled by the researcher. Before this, the intracellular milieu was inaccessible for manipulation, and the electrical activity was measured by means of very sharp penetrating microelectrodes. The only exception was that of giant axons of cephalopods, which could be perfused. The utmost importance of being able to introduce to the cell's interior whatever electrolyte one wanted was demonstrated by the British scientists Alan Hodgkin and Andrew Huxley, who by doing so in the squid giant axon succeeded in deciphering the ionic mechanisms of action potential generation and propagation. The new "intracellular dialysis/perfusion" technique was initially used with giant molluscan neurons, the favourite preparation of the 1960s-80s. However, it proved to be versatile enough to be applied to cells of virtually any type and shape. My father worked at BIPh NASU studying the physiology and biophysics of smooth muscle, and he, for instance, successfully adapted the newly-developed technique to measure membrane currents in isolated smooth muscle cells.

The "intracellular dialysis/perfusion" technique was invented by a group of talented young investigators headed by Prof. Platon G. Kostyuk, the Director of BIPh NASU. At the turn of 1970s and 80s, its utilisation and popularity was at its height. For the first time, with the help of this technique, transmembrane ionic currents of isolated snail neurons were dissected into components, and the Ca^{2+} current was isolated and described. In fact, the technique per se and the results obtained with it became so popular and important that the famous Moscow Institute of Physics and Technology (MIPT, among its professors the Nobel Prize winners L. Landau, P. Kapitsa, N. Semyonov, V. Ginzburg, A. Prokhorov) decided to establish the new Department of Membrane Biophysics with BIPh NASU serving as its base organisation, and Prof. P.G. Kostyuk appointed as its head. The Department started its activity in 1980 with the first admissions to the graduate programme.

And 1980 was the year when my father became increasingly more persistent in trying to convince me that this was a good chance for me to combine physics and biology, and to become a membrane biophysicist. His major arguments were, first, that I would become a graduate student of the extremely prestigious MIPT and, second, that I could still be a physicist but simply studying biological phenomena related to bioelectrogenesis. To come to terms with the idea I thought, “OK, now I'm a physicist studying ion beams and their interaction with vaporised matter, but when I switch to biophysics I will study ion fluxes and their interactions with membranes. Sounds similar, the only difference is in going down in scale, from kiloamps to nanoamps and from megavolts to millivolts, so why not give it a try?”

A visit to BIPh NASU and the interview with Prof. Kostyuk reassured me that it may be the right thing to do. First, I saw "intracellular dialysis/perfusion" rigs, and since they could be operated by one or maximum two persons, they corresponded to my inner urge to do experiments independently of others whenever I liked and could. Second, Prof. Kostyuk said that he preferred young associates with a physics rather than biology background. He reasoned that electrophysiology was the kind of science that required building lots of unique electronic equipment (at least at that time), an understanding and modelling of electric phenomena, and if it came to the lack of some knowledge, it was always easier for a physicist to learn and understand biology than for a biologist to learn and understand physics. So, in 1980 I became a graduate student (as we say an "aspirant") in biophysics at the Department of Membrane Biophysics of MIPT, working under the supervision of Prof. P.G. Kostyuk at his Department of General Physiology at BIPh NASU. Sounds complicated, right? But that is how it was. Legally, I was a graduate student of MIPT receiving my fellowship from Moscow, but physically I was working at BIPh NASU in Kyiv."

Figure 1: Prof. P.G. Kostyuk (1924-2010) in the lab at the beginning of 1980s

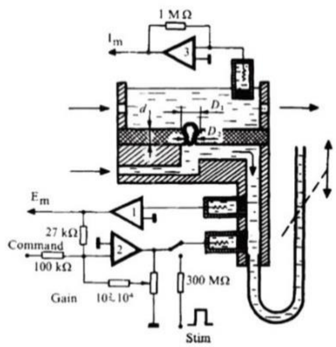

Figure 2: First variant of intracellular dialysis technique with the cell sitting in the conical pore (upper and inner diameters D1 and D2, respectively) punched in the planar polyethylene film of the thickness d.

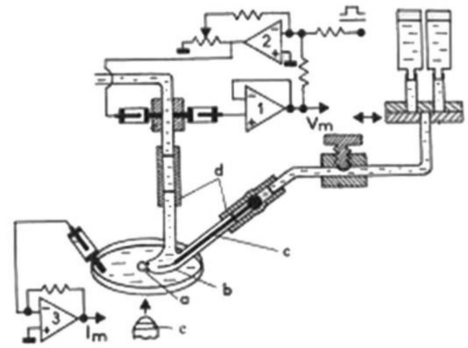

Figure 3: Second variant of intracellular dialysis technique with the cell (a) sitting in the pore made at the top of V-shaped polyethylene tube (b).

Could you tell what it was like being a PhD student in biophysics in Ukraine in the early 1980s?

"Remember, at that time Ukraine was not an independent country, but one of the republics of the Soviet Union called the Soviet Socialist Republic of Ukraine (SSRU). The Soviet Union was a superpower of those times competing with Western countries in all aspects of life to demonstrate to the rest of the world "the advantages of the communist social system" and to establish its worldwide hegemony. One of the areas of competition was science, and I have to admit that being a scientist in the Soviet Union was quite prestigious, and the salaries of the scientists, especially those at advanced stages of their careers were well above average. Nevertheless, the Soviet Union was a very closed country with its infamous "iron curtain" effectively curtailing any communication with the rest of the world. It meant that the majority of people could not freely travel abroad, and only "chosen" scientists who reached the highest positions and proved to be loyal communist party members could represent the country on an international level. The majority of scientists had no choice but to stay in the country and work to promote their careers, in the hope of sometime reaching the status of being "chosen". At the same time, the scientific sphere in the USSR as well as all other spheres of Soviet reality (with probably the one exception of the military-industrial complex and scientific branches working on it) suffered from an inefficient economic system, with an inability to provide a sufficient amount of goods and services. This created a quite unique situation in science, where educated and motivated people had to work under conditions of a chronic shortage of everything and had to demonstrate remarkable creativity to advance the research they were doing.

And that was exactly the situation I faced in 1980 after becoming an "aspirant". After Prof. Kostyuk had given me a tour around his Department, introduced me to his associates and designated a person whom I could consult with on technical issues, we started to discuss my project. Prof. Kostyuk proposed that I should focus on investigating the mechanism of the so called "modification of neuronal voltage-gated calcium channels selectivity by EGTA". But, he said, all intracellular perfusion setups in the Department were occupied "round the clock, 7 days a week", and in order to conduct my experiments I would need to build my own. And this meant, he continued, that I had to ask people and look around (including closets) for pieces of equipment, parts and components that were sitting unused, collect them, then build from scratch an electronic amplifier from the most basic elements (resistors, capacitances, operational amplifiers, etc.), put everything together as a functional setup, test it and then proceed with my experiments. And for technical questions during this endeavor I could consult the person whom he designated to help me.

Fortunately, these tasks did not scare me. By mobilising all the skills and experience acquired during my previous tenure at the Institute of Physics in the "do-it-yourself" business, in about 3 months I was ready to do experiments on my own setup (Figure 4). Frankly, this was a great and very useful experience - first, because I perfectly knew how things worked and how they were built; second, I never had a problem with troubleshooting; third, I could always upgrade my setup to meet new experimental needs. And that is what was needed constantly.

After building my own setup, all that was needed was to use it intensively to generate results. And I had no problem with that, defending my PhD in 1983, just 3 years after admission to the programme. I even published a paper with my results on how calcium ions themselves regulated the selectivity of calcium channels in the *Journal of Membrane Biology* [Kostyuk et al., 1983]. Somebody may say "big deal, just one paper in JMB in 3 years"! But those who might say this have no idea what it was like publishing something in the Soviet Union. An "iron curtain" meant not only having no chance to travel abroad, but also the impossibility to publish something in the open press without being granted permission from the "competent authorities". After writing the paper (in Russian, of course) the authors had to submit it to a 'special commission' (which included, among other members, a KGB representative), who carefully reviewed the manuscript checking that it did not contain any "classified information" or any open or hidden "anti-Soviet sentiments", and gave approval for publication. When a manuscript was intended to be published in the English language in an international journal, the procedure of getting approval was even lengthier and more complex, involving not just one, but several reviewing stages by commissions at different levels. Besides, it was mandatory (and commissions strictly followed this) that everything intended for publication abroad must first be published in some form in the Russian language inside the country. Many good scientists were satisfied with this first stage of publication and did not want to go through the additional hassle of publishing internationally, which is why their research did not receive sufficient attention from the world-wide scientific community. But Prof. Kostyuk was very persistent in persuading his associates to take all possible efforts to publish abroad. And as time showed, this strategy was right because the great achievement of our Institute during those times was to receive international recognition.

Thanks to its high reputation, and in defiance of the "iron curtain", the Institute was able to organise a number of international meetings during the 1980s, dedicated to ion channels research. They were attended by top scientists in the field from the USA, Europe and Japan, including the inventors of the "patch-clamp" technique and future Nobel Prize winners E. Neher and B. Sakmann. And for me their visits were especially useful. The fact is that by the mid-1980s "intracellular perfusion", as a technique of choice allowing the isolation and investigation of whole-cell membrane currents had gradually exhausted itself, whereas the newly introduced "patch-clamp" [Hamill et al., 1981] was at the beginning of its triumphant rise worldwide, enabling a transition to a whole new level of single-channel research. Therefore, Prof. Kostyuk, even before I was done with my PhD thesis, had set a new goal for me - a switch to the "patch-clamp". In our Soviet reality, this meant building a "patch-clamp" setup, including a new amplifier, from scratch and to establish the necessary "ecosystem" for the fabrication of patch pipettes, Silgard coating and pipette tip polishing, relying solely on the descriptions presented in the famous "patch-clamp" paper [Hamill et al., 1981].

Fortunately, E. Neher visited Kyiv several times, and I had a chance to ask him questions and consult on several practical issues, which was very helpful. He also gave me as a gift two key elements without which building the patch-clamp amplifier would have been impossible, and which were simply not available in the USSR. These were a low noise operational amplifier and a high precision gigaohm-range resistor. All in all, it took me almost two years to bring everything to a fully operational state, which included not only building a functional patch-clamp setup, but also writing the software for single-channel data analysis. To accomplish the latter, I had to take a half-year training course on the Assembler and FORTRAN programing languages and to dip into informatics. All these efforts were eventually successfully applied to studying the activity of various types of single calcium channels in neurons, which culminated in publishing three papers in international journals [Kostyuk et al., 1988, 1989, Shuba et al., 1991] (remember what it was like to publish abroad in the USSR?).”

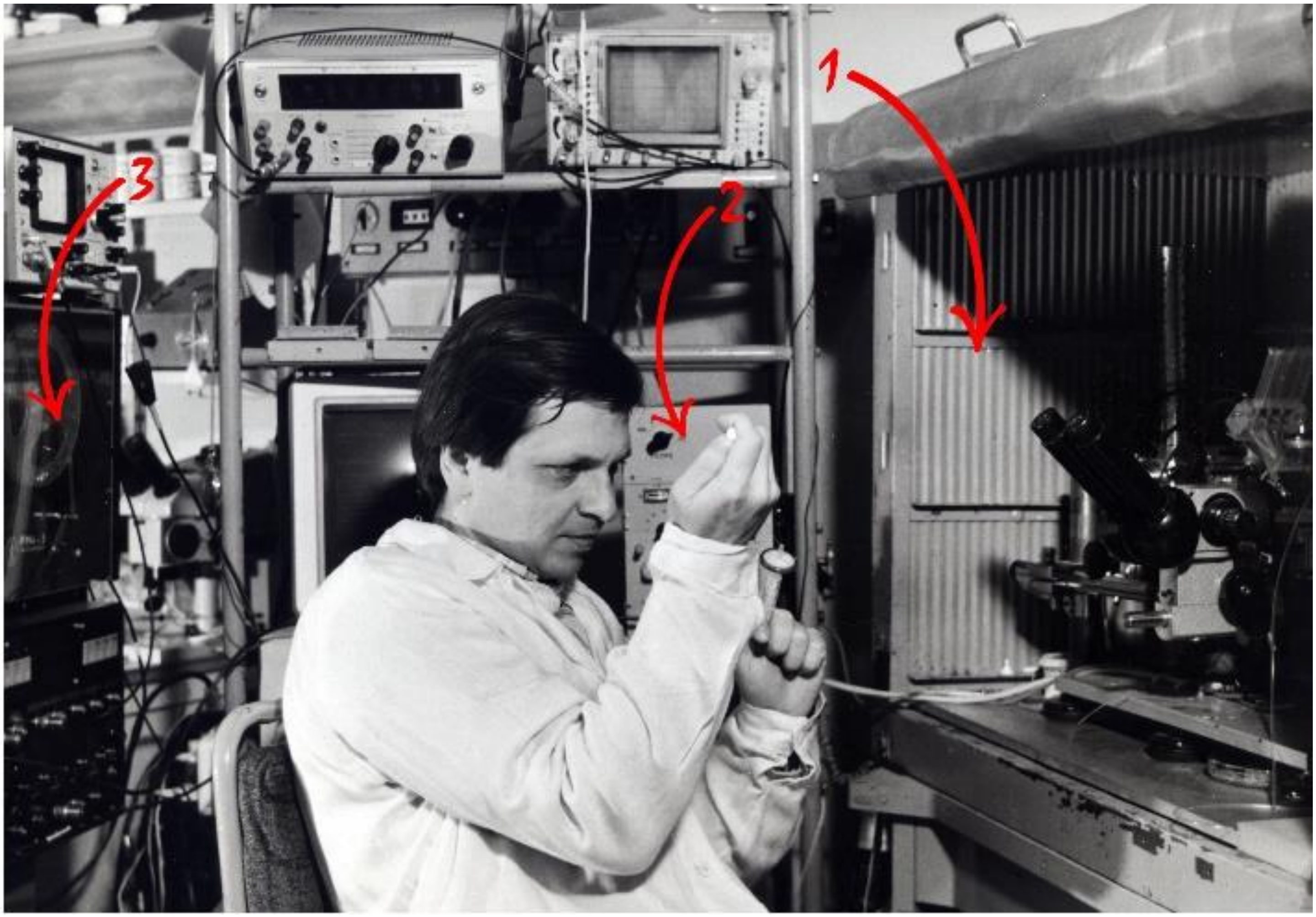

Figure 4: Shuba in the mid-1980s with the self-built electrophysiology rig. 1 – Cabinet from old constant-temperature incubator repurposed for Faraday cage, 2 – Self-made "patch-clamp" amplifier, 3 – Analogue, frequency-modulated magnetic tape data recorder.

Since then, you’ve been working in many labs and studied a whole lot of different types of channels. Moreover, on the website of your lab it’s mentioned that you’ve also developed two experimental techniques – double pipette technique for the rapid dialysis of small cells and perfusion technique for *Xenopus* oocytes. Could you explain about these techniques?

“As I already mentioned, in spite of the "iron curtain", in the 1970s and 1980s the Bogomoletz Institute of Physiology hosted a number of international meetings dedicated to ion channels research, which were attended by top-notch scientists from all over the world. One of such meetings, I believe in 1987, was attended by Prof. Wolfgang Trautwein and his associates. Prof. W. Trautwein was Director of the II Physiological Institute at the Medical University of Saarland in Homburg (in West Germany. Remember, at that time there was also East Germany, belonging to the USSR-led communist camp), and his scientific interest was the beta-adrenergic regulation of calcium channels in the heart. Prof. W. Trautwein had an opening for a short-term visitor in his Institute, and he asked Prof. P. Kostyuk if he could recommend somebody for this position. I was lucky enough that Prof. P. Kostyuk recommended me, and that was how in 1988 for the first time in my life I became close to visiting a "capitalist country". In the early 1980s, I'd already had a chance to be in Hungary and Czechoslovakia as part of a scientific exchange programme within CMEA (Council for Mutual Economic Assistance) countries[1], which earned me the reputation of being a "loyal and reliable Soviet citizen". Besides, the late 1980s was the era of Gorbachev's "perestroika" whose one feature was some lifting of the "iron curtain". Altogether, it helped me to eventually get approval from the Soviet authorities to go to West Germany in 1988 for 6 months to work in Prof. W. Trautwein's lab in Homburg.

The time in Homburg was very productive in terms of research and useful in terms of establishing new contacts, as Prof. W. Trautwein's lab was a really international one. In close interaction with Dieter Pelzer and later on with Terence McDonald, who arrived from Canada, I studied there the effects of G protein activation, as part of a beta-adrenergic regulatory cascade, on the calcium current in cardiac myocytes. To do this work it was necessary to deliver GTP and its analogues into the myocyte during whole-cell patch-clamp recording of the calcium current . Thus, we decided to use in addition to the main patch pipette, a second one supplemented with these compounds. With the help of the second pipette we could actually perfuse the myocyte by applying positive pressure to it and also measure the real voltage inside the myocyte. That was, in fact, the essence of the double pipette technique for the rapid dialysis of small cells. We described this method in the special technical paper in *Pflugers Archive* [Shuba et al., 1990]. This small methodological advancement was a kind of continuation of my "do-it-yourself" approach acquired in Kyiv.

Prof. W. Trautwein was frequently communicating with scientists around the world working in the field of cardiac electrophysiology (by the way, many of them went through his lab as postdocs or vising scientists). And that was how the rumours about a "Russian" (everybody from Soviet Union was considered "Russian" in the West) who could think slightly beyond traditional approaches got to the ears of some other people from the field. Among them were Terence McDonald (Canada) and Martin Morad (USA) who maintained close ties with Trautwein's lab, and with whom I became also personally acquainted. I agreed with them that after returning back to Kyiv and settling all my matters there, we would attempt to arrange professional visits - first to Canada and then to the USA - to continue working on cardiac electrophysiology.

This became possible only in 1991, as the Soviet totalitarian grip essentially weakened, and at the end of which the Soviet Union ceased to exist. Thus, in 1991-93 I worked with T. McDonald at Dalhousie University (Halifax, Canada) and between 1993-96 with M. Morad at Georgetown University (Washington DC, USA).

I am telling all this to provide some background to the answer to the second question about perfusion technique for *Xenopus* oocytes. While working with Martin Morad, we were interested in the beta-adrenergic regulation of the cardiac sodium-calcium exchanger and the pharmacological regulation of the HERG potassium channel. To be able to work with membrane currents associated with the functioning of each of these membrane proteins in isolation, with no contamination from other currents, we decided to experiment not on native cardiac myocytes, but to use recombinant forms of these proteins expressed in *Xenopus* oocytes. However, I was always unhappy with two shortcomings of *Xenopus* oocytes in terms of electrophysiology. First, the quite slow speed of the voltage-clamp with traditional two microelectrodes technology and, second, the inaccessibility of the oocyte's interior for dialysis or perfusion. So, I thought why not try to perfuse the oocyte and use the perfusion pore as a means of low-resistance access to the oocyte's interior for the voltage-clamp. Some of these approaches were described in the literature, but ours capitalised on the strong adhesion of the oocyte, devoid of the vitelline envelope, to the glass. We called this technique a "glass-funnel" one, because the devitellinated oocyte was positioned at the bottom of a miniature funnel made of glass to form a high resistance seal between the oocyte's membrane and the funnel walls. The part of the oocyte facing the funnel's interior represented a working part and the one protruding out of the funnel was destroyed to get access to the inside of oocyte. We successfully used this technique in all our studies at Georgetown, and again described it in the technical paper in *Pflüger's Archive* [Shuba et al., 1996]."

What projects are you working on now?

“In 1991 I left the USSR, but in 1997 I returned to a completely different country called independent Ukraine. Unfortunately, the disintegration of the Soviet Union and the transition from one big, centrally-controlled, planned economy to many smaller free market economies, but with broken ties, did not bring economic prosperity to the newly independent states (NIS) that comprised the former USSR. Moreover, the economies of these states, and Ukraine was no exception, basically collapsed, with economic hardships negatively impacting all spheres of life, with science probably suffering the most. As the "iron curtain" suddenly came down whilst economies deteriorated, many active former USSR scientists fled their newly independent home countries in search of new opportunities to apply their knowledge and for better economic conditions abroad. So, I appeared in a unique situation: at a time when all my scientific peers were moving to the West, I was moving in the opposite direction back to Ukraine.

Fortunately, the USA and European Union established several research grant programmes specifically aimed at fostering collaboration between scientists from the former Soviet Union and those from the USA and EU countries. The main aim of these programmes was to keep researchers from the former USSR, especially those who were somehow linked with the Soviet military complex, from immigrating to "rogue states". These programmes did not prevent the "brain drain", but provided at least some support to those who opted to stay. I got several such collaborative grants, which helped me to continue my scientific carrier in Ukraine and to stay in permanent professional contact with my friends and colleagues abroad.

I was working on a variety of projects, the most important of which included the hormonal and pharmacological regulation of cardiac potassium channels, selectivity, permeation and pharmacology of T-type calcium channels, ion channel involvement in carcinogenesis, and in urinary bladder dysfunction. We are trying to pursue a whole new direction, which we call "X-opto-pharmacology". But I don't want to get into any specifics beforehand. Hopefully, you will learn about it from our publications.”

Tell about the past and present of ion channel research in Ukraine (big names, big discoveries, Ukrainian ion channel scientists abroad, current ion channel centers, labs, meetings, societies, associations, companies).

Figure 5. Prof. D. Vorontsov (1886-1965).

“The beginning of ion channels research in Ukraine, or since we are talking about the first half of the 20th century more correctly would be to say electrophysiological research, is commonly associated with the name of Prof. D. Vorontsov (1886-1965), Figure 5), who chaired the Department of Electrophysiology at Bogomoletz Institute of Physiology during the years 1956-1965.

But the real boost this field of research received in the 1960s and 1970s was due to the efforts of his students. These included Prof. Platon Kostyuk in application to general neurophysiology, Prof. Michael Shuba (my father, by the way) in application to smooth muscle physiology and Prof. Vladimir Skok in application to the autonomic nervous system. The culmination of these efforts was in the elaboration and introduction to research practice of the "intracellular dialysis/perfusion" method by P. Kostyuk and his associates, O. Krishtal and V. Pidoplichko [Kostyuk et al., 1975]. During the 1970s and 1980s this enabled the first in-depth description of the voltage-gated calcium current in nerve cells. This was followed by the discovery of proton-gated channels [Krishtal and Pidoplichko, 1981] and the membrane receptor for extracellular ATP [Krishtal et al., 1983]. As I already mentioned, publishing scientific papers in the Soviet Union, especially in English language international journals, was not an easy task. Therefore, some of the discoveries, which were first published in Russian language Soviet journals, frequently went unnoticed by the international scientific community. In particular, the discovery of low voltage-activated (or T-type) calcium channels was published in Russian in 1983 [Veselovskii and Fedulova, 1983], but only 2 years later in English, during which time a similar publication had appeared in the West. To commemorate the 25th anniversary of this discovery, in 2008 we organised an international meeting in Kyiv called *"T-type calcium channels: from discovery to channelopathies, 25 years of research*" [Shuba et al., 2008] which was attended by top experts in the field. The meeting was extremely successful, and left many good memories for the participants, who all, by the way, recognised the priority of our Institute in the T-channel discovery."

You said that a lot of Ukrainian researchers left the country and are now working abroad. So, what about the next generation of Ukrainian scientists? Are Ukrainian students interested in pursuing a scientific career, in particular in biophysics?

"After moving to the USA and Europe during the 1990s and 2000s, many of our former associates brought their electrophysiology and ion channel expertise which they acquired in our Institute to their new places of employment, promoting the Institute's international reputation. However, in post-independence Ukraine, economic hardships and chronic science underfunding largely deterred and continue to deter young people from pursuing scientific careers. Therefore, there is no adequate replacement by a younger generation of the researchers who left the country, which is why scientific human resources are gradually shrinking. Besides, the younger generation does not show the same motivation, drive and skills for doing science as the previous generation did. The situation can be reversed only by making research activities more attractive in terms of social prestige (at least as it was in the USSR), sufficiently high wages, career growth prospects and a tighter integration into the world and European scientific space. This is quite a complicated issue, requiring reform of the entire scientific sphere in Ukraine."

There are rumours that you have an interesting project that is not at all related to ion channels. It's called the ShubaEngine. Could you tell something about it?

"Yes, this is my hobby outside ion channels. I am fond of automobiles, engines and everything that surrounds them. So, I always wondered why in the internal combustion engine the energy of combusted fuel cannot directly drive the rotation of the shaft instead of first producing a linear reciprocating motion of the pistons, which only then is transformed to rotary motion with the help of connecting rods and the crankshaft. This would reduce energy losses associated with the existence of this transformation mechanism. And this is how I came up with the new concept of the rotary internal combustion engine (RICE) which in my USA patent is called the *Shuba engine*. This is analogous with the Wankel engine, so far the most widely adopted type of RICE and named after its inventor, German engineer, Felix Wankel. Anyone who is interested in the technical details of the design can Google "shuba engine".

I understand that we are at the doorstep of an electric vehicles (EV) revolution. However, gasoline which is currently the most popular fuel for cars contains an energy density about 100 times higher by both weight and volume (i.e. 47.5 MJ/kg and 34.6 MJ/liter, respectively) than the most advanced lithium-ion battery (i.e. about 0.3 MJ/kg and 0.4 MJ/liter, respectively) used in modern EVs. Even considering the higher efficiency of an electric motor in converting battery-accumulated electric energy to car movement (typically 60-80%) compared to that of the internal combustion engine in converting gasoline-stored thermal energy (typically 15-20%), the battery must possess an energy storage density at least 1/5 of that of gasoline to provide the same range as a gasoline-powered car.

Thus, electric batteries still have a long way to go in terms of higher energy storage density and a lower cost in order for EVs to find widespread utility outside a limited market of urban transportation. Besides, creating battery-charging infrastructures and essentially increasing the proportion of green power-generating facilities (it doesn't matter for the environment where carbon dioxide is coming from, conventional vehicles exhaust pipes or smokestacks of electricitygenerating fossil fuels-burning power plants) would require time and effort as well. In the meantime I believe that hybrid power systems that combine gasoline engines with electric battery and motor components helping to enhance fuel efficiency and reduce pollution will remain a viable alternative. Altogether, this makes the development of new and improving existing gasoline engines still a priority, and the Shuba engine would be perfect to work in hybrid systems.

However, conceiving the design of the Shuba engine and patenting it appeared nothing compared to the challenges associated with building a working prototype. Even though I've done a lot of preparatory work by myself - creating computer animations, building a real metal model, making drawings of all the parts (i.e. creating technical documentation) and placing all these materials on the internet, I still have a problem finding a manufacturer to build a working prototype of the engine. Big car manufacturers say that they have their own development programmes and don't want to deal with outside intellectual property, whilst other metalworking companies most likely see the project as relatively complex, but not very profitable for them. However, this is a typical situation with any invention. By the way, Felix Wankel patented his engine in 1929, but the first prototype was built only in 1957. So, I am not losing optimism and keep trying. Using the opportunity, I ask anybody who sees this interview and has some connection with the companies involved in high-tech metalworking (CNC machining, 3D printing, casting) to please refer the Shuba engine to them."

Russia's aggression against Ukraine is the major geopolitical disaster of today. What is your opinion on the situation, how can it be resolved and how do you see the future of Ukrainian science?

"Historically, the people of what is now known as independent Ukraine have not had a straightforward relationship with the state led by Russians, no matter what this state was called – be it Muscovite Tsardom, Russian Empire, USSR or the Russian Federation. These relationships were characterised by a significant degree of superiority of Russians towards Ukrainians, similar to the "younger brother" who is not that smart, speaks a strange language, is not self-sufficient, needs to be controlled and is not to be trusted. It actually led to the denomination of Ukrainians as "small Russians" ('Malorosy'), as opposed to real or "great Russians" ('Velikorosy'). But Malorosy could easily convert into Velikorosy simply by forgetting their language and ethnic background - and history is full of such examples. However, most Ukrainians were not happy with such a situation, leading to an almost constant (with some ups and downs) movement for independence, which Russians managed to control, either by combining repression with the activity of a "fifth column" or simply suppression by direct military force.

When the USSR, as a state based on an unviable social system, disintegrated in 1991 many were surprised that it went relatively peacefully. They hoped that the New Independent States (NIS) of the former Soviet Union, among which was Ukraine, would find new forms of collaboration with each other and move towards higher levels of prosperity, while remaining good neighbours. But this group did not include those hardcore Russians with imperialist thinking in the Russian Federation, which became the successor to what was once the USSR. Led by Putin and his clique, they immediately started to hatch plans and make preparations for taking revenge for the defeat of the Soviet Union in the Cold War and to restore not only its boundaries, but potentially its dominance over the former Warsaw Pact[2] countries. And Ukraine became the first and primary target of such policies, which eventually culminated in the current war. The world community should not be fooled by the official appeals of Putin and his clique, who claim a threat from NATO and far-fetched oppression by Ukraine of the Russian-speaking population, as reasons for their "limited military operation". Their real aim, which they hesitate to proclaim openly because it sounds too Nazi-like, is a "final solution to the Ukrainian question", which means the elimination of Ukrainian statehood, seizing Ukrainian territory, the extermination or displacement of nationally-conscious Ukrainians, whilst turning the rest back into Malorosy. Thus, Ukraine has no choice but to win this war with the help of the rest of the world, and then to remain strong in order to coexist with such an aggressive neighbour and deter it from further aggressive actions. And good science is an integral component of being strong.

Ukraine and the Ukrainian people are demonstrating an unprecedented resolve and courage in this war in protecting their sovereignty, integrity and independence, which has earned them the well-deserved admiration in the world. However, it comes at the cost of great human and material losses, with the scientific sphere in particular being hit very hard. The scientific infrastructure in the Eastern part of Ukraine is basically ruined, while institutions in other parts of the country are barely functioning because of the threats of air raids, reduced funding and because many researchers simply fled the country. It is difficult to talk about returning to our usual scientific activities before the security situation returns to some kind of normality. But then Ukrainian science will need help to revive itself. And not in the form of position openings or exchanges for Ukrainian researchers to go to Western scientific institutions (further exacerbating the already considerable brain drain), but in the form of grant programmes specifically aimed at involving Ukrainian laboratories in collaborative research with Western partners. A good example was an EU programme called INTAS (International Association for the Promotion of Cooperation with Scientists from the New Independent States of the former Soviet Union), which was established in 1993 to foster collaboration between scientists from the NIS of the former USSR and EU countries. Unfortunately, this programme was closed in 2006, but it may now serve as a template for creating new ones for Ukraine. Various wealthy countries may design similar programmes of their own. This will help Ukrainian science to start again on a new financial and organisational foundation, which will eventually benefit world science. Some steps in this respect have already been taken in Ukraine. Most importantly, the National Research Foundation of Ukraine has been created which, despite some teething problems, is expected to replace the old, Soviet-style, distributive system of science funding with a new competitive one."

Disclaimer: The views expressed in the interview are personal and do not necessarily represent the views of the Academia Europaea or Cardiff University. Read **Academia Europaea's statement on Ukraine**.

Footnotes

[1]Economic organisation existing during 1949 to 1991 comprised of the Eastern Bloc socialist states, under the leadership of the Soviet Union.

[2]Warsaw Pact – the military organisation of the Eastern European socialist states led by the USSR, which was created in 1955 in opposition to NATO and dissolved in 1991.

References

Hamill OP, Marty A, Neher E, Sakmann B, Sigworth FJ (1981) Improved patch-clamp techniques for high-resolution current recording from cells and cell-free membrane patches. Pflugers Arch. 391(2):85-100.

Kostyuk PG, Krishtal OA, Pidoplichko VI. Effect of internal fluoride and phosphate on membrane currents during intracellular dialysis of nerve cells. Nature. 1975 Oct 23;257(5528):691-3.

Kostyuk PG, Mironov SL, Shuba YaM (1983) Two ion-selecting filters in the calcium channel of the somatic membrane of mollusc neurons. J Membr Biol 76:83-93.

Kostyuk PG, Shuba YaM, Savchenko AN (1988) Three types of calcium channels in the membrane of mouse sensory neurons. Pflugers Arch. 411(6):661-9.

Kostyuk PG, Shuba YaM, Teslenko VI (1989) Activation kinetics of single high-threshold calcium channels in the membrane of sensory neurons from mouse embryos. J Membr Biol. 110(1):29-38.

Krishtal OA, Marchenko SM, Pidoplichko VI. Receptor for ATP in the membrane of mammalian sensory neurones. Neurosci Lett. 1983 Jan 31;35(1):41-5.

Krishtal OA, Pidoplichko VI. A "receptor" for protons in small neurons of trigeminal ganglia: possible role in nociception. Neurosci Lett. 1981 Jul 17;24(3):243-6.

Shuba YM, Hesslinger B, Trautwein W, McDonald TF, Pelzer D. A dual-pipette technique that permits rapid internal dialysis and membrane potential measurement in voltage-clamped cardiomyocytes. Pflugers Arch. 1990 Mar;415(6):767-73.

Shuba YM, Naidenov VG, Morad M. Glass-funnel technique for the recording of membrane currents and intracellular perfusion of Xenopus oocytes. Pflugers Arch. 1996 Jul;432(3):562-70.

Shuba YM, Perez-Reyes E, Lory P, Noebels J. T-type calcium channels: from discovery to channelopathies, 25 years of research. Channels (Austin). 2008 Jul-Aug;2(4):299-302.

Shuba YM, Teslenko VI, Savchenko AN, Pogorelaya NH (1991) The effect of permeant ions on single calcium channel activation in mouse neuroblastoma cells: ion-channel interaction. J Physiol. 443:25-44.

Veselovskiĭ NS, Fedulova SA. [2 types of calcium channels in the somatic membrane of spinal ganglion neurons in the rat]. Dokl Akad Nauk SSSR. 1983;268(3):747-50. [in Russian]