SERGIY GULYAR: VITAL PROGRESS AND CONTRIBUTION TO THE DEVELOPMENT OF UNDERWATER PHYSIOLOGY AND MEDICINE SCIENCES

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ABSTRACTS

Here we present a unique life path of Sergiy Gulyar, a world-known Ukrainian scientist who was overcoming extreme conditions studying them on himself. He has developed his determination and responsibility from his basic experiences as a surgeon and his desire to win from his involvement in sports. His research in underwater laboratories has shown a capacity to find untrodden pathways to understand and explain what others did not even suspect. His physiological studies on the role of sea depths, breathing mixtures, underwater exposures, and diving schemes marked the path to the aquanauts and undersea man. Reaching the hyper depths equivalent to 2,500 m revealed the physiological limits of human being and defined how to handle hyperbaric respiratory failure. Prof. S. Gulyar suggested a usage of natural physiological mechanisms to accelerate the re-adaptation process as a part of the high-mountain rehabilitation of hyperbaria-adapted people. Dissertations were defended, books and articles were written, a scientific school of followers was created. Unfortunately, during the Soviet period, Prof. S. Gulyar faced a set of organizational problems and obstacles from the Soviet regime. In particular, his works were classified or hushed up, his intellectual property was often used without mentioning the author and his scientific team was intimidated by criminal investigations. Main recognition during this period had come from professional societies in Europe and the United States. After the collapse of the Union of Soviet Socialist Republics (USSR), Prof. S. Gulyar introduced a number of innovations and inventions in electromagnetic medicine and physiology. In particular, he has managed to account for main common features of physiological effects of light stimulation produced by Lasers, Light-Emitted Diodes and Bioptron light sources. By doing so, some mystical dogmas were filtered out and new paths to sensible light-induced treatments were developed. At the same time, Prof. S. Gulyar has preserved the legacy of many generations of medical professionals who used light in their treatments. He has shown in his physiological experiments that stimulation of biologically active zones including acupuncture points light stimulation has a wide spectrum of biological effects including alleviation of pain symptoms. Now mono- and polychromatic visual and transcutaneous light therapy of pain has been recognized scientifically and clinically, and its place in medicine has been firmly established. Prof. S. Gulyar described a new functional system of the organism that regulates the electromagnetic equilibrium. A step into the future was the first experimentally grounded technology for the use of fullerene-modified light. Positive changes have been proven with its percutaneous and ocular use. These first results open the door to complete analysis and future investigations. Prof. S. Gulyar has published 20 monographs, 470 papers and abstracts, and received 11 patents. Many of his inventions have been implemented, the others are still awaiting implementation. This article is based on the data obtained by the authors during many years of their personal cooperation, as well as from the memoirs of Prof. S. Gulyar and the materials he provided.
Keywords: underwater medicine, compressed air works, Ichthyander and Chernomor underwater laboratories, pressure chambers, hyperbaria, nitrox, heliox, neonox, decompression, oxygen balance, adaptation, saturation diving, general high-pressure syndrome, Bioptron, Medolight, polarized light therapy, fullerene, historical modeling, ancient Slavic boat, underwater archeology, Bogomoletz Institute of Physiology of NASU, Bohaterow Westerplatte Polish Naval Academy, Zepter International Company.

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LIFE'S MILESTONES

In 2022, Prof. Sergiy Gulyar, MD, PhD, DSc celebrates his 80th birthday. He is a leading researcher at the Bogomoletz Institute of Physiology of the National Academy of Sciences of Ukraine (NASU). Dr. S. Gulyar made significant scientific contributions to the human physiology in extreme conditions, hyperbaric medicine, and the development of light therapy technologies. His works are recognized by scientists worldwide [1-7].

Sergiy Gulyar was born on November 4, 1942 in the Donbass (Ukraine), studied medicine at the Donetsk Medical University and graduated with honors in 1965. While studying at the Medical Institute, Dr. S. Gulyar was fond of motorcycling and scuba diving and achieved serious success. Over time, Dr. S. Gulyar became a professional diver. Motocross and motorcycle tourism were a school of extreme risk for him; such an experience gained in overcoming extreme loads will allow him to survive in various life situations. Dr. S. Gulyar still remembers the motorcycle assault on the Elbrus glaciers in 1963 as a one of the riskiest challenges.

At the senior courses of the University, he had worked for 3 years as an urgent surgical nurse in Donetsk' hospitals. After graduating from the University, Dr. S. Gulyar started his medical carrier as a surgeon—abdominal surgery, traumatology, anesthesiology—at the hospital in Toretsk, Donetsk region. At the same time, he taught surgery and physiology at a medical college (1965-68). Later, Dr. S. Gulyar taught at the Donetsk State University at the Department of Medical Training of Students for Peace and Wartime (1968-1973).

The Donetsk region of those years for the surgeon was the scene of a daily struggle for the life of miners, who often received severe injuries in mines that had not changed much since the beginning of the last century. Many other industrial enterprises of Donbass turned out to be traumatic as well. Working as a surgeon taught Dr. S. Gulyar to react quickly and make the right decisions under time pressure.

THE FIRST STAGE OF SCIENTIFIC ACTIVITY

In parallel with practical surgery, Dr. S. Gulyar began to engage in scientific work. Personal sport achievements and professional success in diving prompted him to research in the field of underwater physiology, which he started in the late 60s of the twentieth century. Under the conditions of saturation stay of aquanauts in the underwater laboratories, new data were obtained in the field of adaptation of the human body to deep-sea conditions. Underwater laboratories Ichthyander-66-68 were the first experimental underwater facilities in the USSR and entered the top ten world laboratories of this type [8-14]. They made it possible for a person to stay for many days at depths of up to 12 m with full saturation of tissues with nitrogen. An outstanding result of these studies was the proof of the phase pattern of adaptation to hyperbaria, which made it possible to scientifically prove the possibility of a person being under water for many days [15-17]. It should be noted that Dr. S. Gulyar performed part of the research on himself, being an aquanaut of the underwater laboratory Ichthyander-67 (Fig. 1).

The obtained data became the basis for the development of methods for optimizing the regimes of a long stay of a person under water (1966-67). These were high-risk jobs. The episode of the struggle for the survival of the underwater laboratory Ichthyander-67 during its emergency flooding is noteworthy. Dr. S. Gulyar, realizing the threat of decompression sickness, continued to stay on watch, provided communication under water and with ground services, evacuated aquanauts, which eventually made it possible to save both the underwater laboratory and the entire expensive experiment.

In the experiments carried out in the underwater laboratories Ichthyander and in the climatic pressure chamber of the Institute of Mine Rescue Affairs of the USSR, original studies of the functioning of the cardio-respiratory system and a human higher nervous activity in hyperoxic conditions and under water were also developed and carried out. At the same time, the first underwater observations of the individual and group psychology of aquanauts were also performed.

A

B

Fig. 1 Dr. S. Gulyar (left in the front row) as part of the first crew of the underwater laboratory Ichthyander-67 (A), which is shown in section in Diagram (B) (1967): (A) 5-seat habitable underwater structure, consisting of 3 compartments with an entrance vestibule, designed for work of aquanauts at depths up to 40 m without access to the surface, with full saturation of organism tissues with compressed air components. The underwater laboratory was installed in August 1967 on the shelf of the Black Sea in Ukraine (Crimea, Laspi Bay) at a depth of 14 m. The exposure of each of the 2 crews under hyperbaria was 7 days, decompression: up to 6 h.

In the early 70s, in some experiments, the longest 36-hour-autonomous stay of a person in a special pressure suit with individual life support systems was achieved ("personal underwater home") [18,19]. At that time, Dr. S. Gulyar and colleagues carried out multi-day studies of thermoregulation and diet optimization under extreme conditions of survival after sea accidents [20-23]. These studies answered many questions about human physiology in extreme conditions, and the technology itself still has no analogues. In 1969-1970, the first database of physiological data of aquanauts wearing various types of protective equipment while performing underwater geological and drilling operations was created.

During these years, under the conditions of the totalitarian regime of the USSR, underwater research, which was carried out by teams of non-military organizations, was artificially hampered by the naval departments, which did not have the necessary intellectual resources. In the future, the scientific direction associated with underwater physiology was completely classified. Scientists were forbidden to publish their data, which caused heavy damage to research teams and the country.

In 1971 Dr. S. Gulyar defended his PhD thesis "Functional Shifts in the Human Organism when Staying in Underwater Laboratories at Shallow Depths", which was prepared on the basis of data obtained in the underwater laboratories Ichthyander [24]. This work, for the first time in the world, was devoted to the study of the physiology of a human who is under water for a long time in compressed air with the tissues completely saturated with nitrogen.

The Second Stage of Scientific Activity

Further scientific research by Dr. S. Gulyar for many years was carried out at the Bogomoletz Institute of Physiology of NASU. In 1973, he was recruited by competition to the position of junior and then senior researcher at the Laboratory of Applied Problems (headed by Prof. A. Z. Kolchinskaya). All these years, Dr. S. Gulyar has been focused on studying the physiological mechanisms of adaptation of the human organism to extreme environmental conditions: underwater, sea, hyperbaric and hypobaric, high-mountain, arctic, antarctic, as well as to conditions of radiation and chemical pollution. He continued to personally take part in hyperbaric experiments to obtain physiological data at higher pressures and various compositions of gas mixtures. In particular, the physiological parameters of aquanauts were studied in the Chernomor underwater laboratories (nitrox and depths up to 30 m), in hyperbaric complexes at depths of 40-450 m (nitrox, heliox, neonox) and in real sea conditions (up to 300 m, heliox) [25-29].

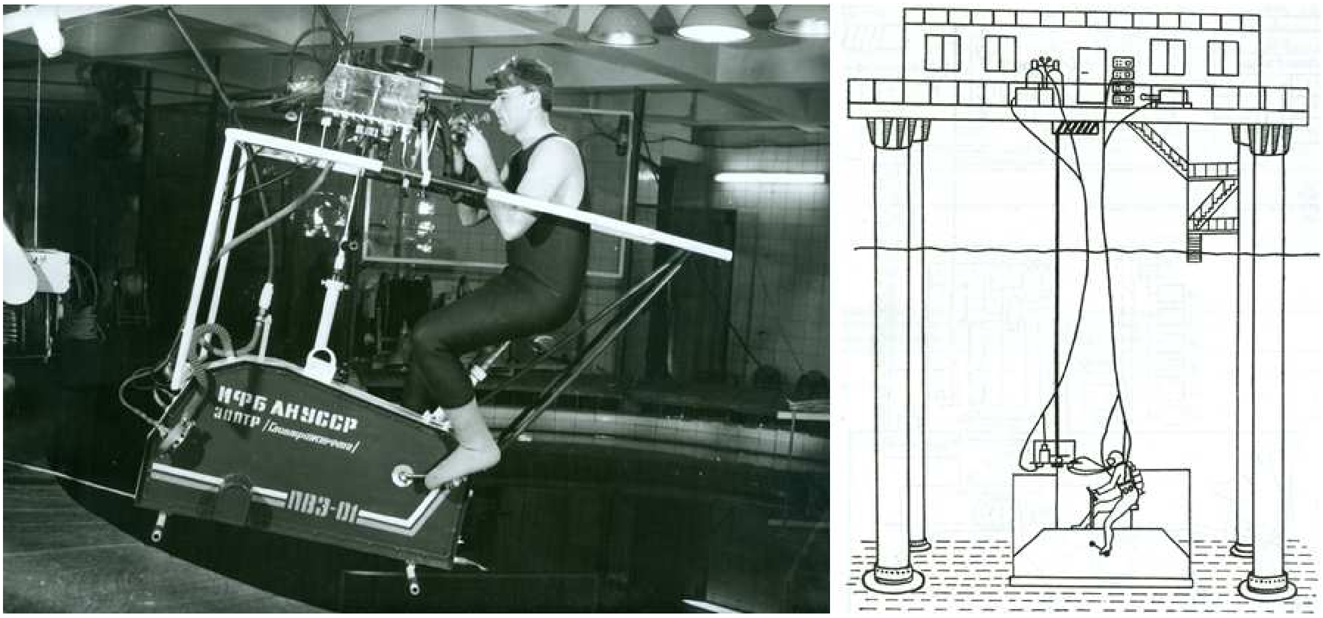
The Third Stage of Scientific Activity

Sergiy Gulyar became head of the Laboratory and then head of the Department of Underwater Physiology at the Bogomoletz Institute of Physiology of NASU in 1980. The main objective of Dr. S. Gulyar research was to identify mechanisms of the relationship between an organism and the altered gaseous environment in hyperbaria. During these years, it was proven that the human organism could adapt to a long stay in a nitrogen-oxygen environment at depths of up to 40 m. At the same time, the features of the reactions to respiration, blood circulation, blood and the physiological costs of the aquanaut's adaptation to various hyperbaria factors were revealed: barometric pressure, density and gas composition. Decompression studies performed at a depth of 10-100 m yield remarkable data (1971-1972). In four series of multi-day exposures at full saturation using compressed air at depths of 10-20-30 and 40 m (zero horizons), aquanauts dived to a depth of up to 100 m. The ability to dive "from new zero" in standard decompression modes has been proven by Dr. S. Gulyar and colleagues. In combination with saturation diving technology, the results of the study had a significant impact on no-decompression stays of up to 100 m at depths of 10-40 m. At the same time, the limit of using compressed air (hypernitroemia + hyperoxia) for such dives was reached. On the 17th day of exposure at a depth of 40 m, one of the aquanauts developed acute nitrogen psychosis according to Dr. S. Gulyar's opinion due to nitrogen narcosis. This required a decompression emergency which luckily was successful [28,29].

In the 1980s, Dr. S. Gulyar took part in the State Program for Research on Dolphin Breathing. In unique experiments, Dr. S. Gulyar was the first in the world to carry out a series of "dives" to a depth of 30 m in a pressure chamber together with a dolphin. Then scientists in this field were interested in the question of whether a dolphin can breathe at elevated pressure—after all, it has an evolutionarily developed mechanism for automatic blockade of the respiratory valve. In this experiment, there was a danger to the life of the experimenter. However, the experiment was successfully carried out; unique data on the oxygen regime of the dolphin's body were obtained. The possibility of breathing at elevated pressure has been proven. This opened up the prospect of creating dolphins-aquanauts. Unfortunately, due to the secrecy regime, these data were not published. The same fate befell the unique experimental proof of the possibility of non-decompression ascent of animals from a depth of 100 m against the background of the use of enterosorption drugs.

Economics always poses certain tasks for researchers. So, the development of the continental shelf in the 70-80s significantly was hampered by the unresolved physiological problems of deep-sea diving. One of the important tasks was to solve the problem of optimizing the gas environment and its physiological safety for humans. To solve this problem, Dr. S. Gulyar developed a methodology for studying the respiratory, hemodynamic and biochemical mechanisms of regulation of the transport of respiratory gases in the body under the influence of high pressure artificial atmosphere from different proportions of oxygen, nitrogen, helium and neon. For the first time in the world practice of diving, the oxygen regimes of the organism of aquanauts were characterized [30-33].

With colleagues from his department, Dr. S. Gulyar studied the effect of various muscle loads in water on the organism (Fig. 2). This made it possible to get direct data and describe the pathogenesis of the integral syndrome of high pressure associated with a violation of the transfer of respiratory gases during hyperbaria (at rest and during work in water). Scientists have studied in detail its constituent components: nervous, respiratory, circulation, exchange, compression and post-decompression. This became the basis for the development of therapeutic and preventive measures to preserve the health and working capacity of aquanauts, improve the efficiency and safety of their work at all depths accessible to a person in diving equipment [19, 20, 22, 34-36].



A B

Fig. 2 Experimental complex for underwater bicycle ergometry before the start of research in the deep-sea basin (A, diver V. Mikhailusenko) and scheme of the experiment in real conditions (B) (1988).

In 1983 Dr. S. Gulyar defended his doctoral dissertation “Respiratory and Hemodynamic Mechanisms of Regulation of the Oxygen Regimes of the Human Organism under Hyperbaria” [37]. Under his scientific supervision, 5 PhD and 4 doctoral dissertations were defended (Fig. 3). In 1993, Dr. S. Gulyar was awarded the academic title of Professor in the specialty “Human and Animal Physiology”.

Further studies showed the role of hyperbaric factors—increased compression ratio, hyperoxia, high partial pressure in respiratory mixtures of nitrogen, helium, and neon—in the development of functional changes in respiration, blood circulation, and oxygen regime in deep-sea divers. Contrary to the traditional approach, which postulated the need to use an increased oxygen content in respiratory gas mixtures, which dominated the world practice of deep-sea work and led to the development of “oxygen” pathology, Prof. S. Gulyar proved the absence of arterial hypoxemia in normoxia high-density respiratory environment. Using the data of the dynamic analysis of the oxygen regimes of the organism, he developed and applied a new effective method for the biological correction of the partial pressure of oxygen in residential hyperbaric underwater structures [38, 39]. As a result, new modes of operation of the life support systems of hyperbaric structures were substantiated and eventually introduced into official practice.

Fig. 3 Department of Underwater Physiology, Bogomoletz Institute of Physiology, National Academy of Sciences of Ukraine (Head: Prof. S. Gulyar, in the center of the first row) (1989).

Based on the data obtained in model (pressure chamber "depths" up to 450 m) and real (up to 300 m, shelf of the Barents Sea) diving, Prof. S. Gulyar and his colleagues developed an expert system for calculating the maximum human energy consumption during underwater work as well as a methodology for ergonomic evaluation of new underwater technologies [40,41].

The development of original methodological methods for recording breathing parameters made it possible for Prof. S. Gulyar to perform in the mid-80s unique studies of human breathing in a hyperbaric neonox medium at depths equivalent to 250 m in heliox, at an extreme 32-fold density (Fig. 4). International complex experiment was conducted by scientists from the Southern Branch of the Shirshov Institute of Oceanology of the Russian Academy of Sciences, the Bogomolets Institute of Physiology of NASU, the Central Laboratory for Brain Studies of the Bulgarian Academy of Sciences, and the Institute of Biomedical Problems of the Russian Academy of Sciences. In this experiment, a previously unknown respiratory syndrome was identified and described, which occurs with high resistance to breathing, the leading phenomenon of which is oscillations of respiratory flows in the bronchi. A new mechanism that allows the movement of superdense gas in the respiratory tract is the appearance of the second exponent of the respiratory flow velocities in the bronchi of medium and small caliber [42-45].

A

B C

Fig. 4 Complex of hyperbaric chambers for saturation experiments (N_2 + He/Ne + O_2) at “depths” of 450 m (Shirshov Institute of Oceanology of Russian Academy of Sciences, Gelendzhik, 1988): Four aquanauts were in the pressure living compartment, above which was located a complex of recording equipment (A). Exposure under pressure, including decompression, was up to 30 days. Examination of aquanauts while exercising in a pressure chamber: (B) registration of physiological variables through communication connections in the pressure chamber (Prof. S. Gulyar), (C) an aquanaut under high pressure performs a bicycle ergometric load with registration of indicators of the oxygen regime of the organism.

The results of research in the field of hyperbaric physiology are reflected by Prof. S. Gulyar in his monographs The Human Organism and the Underwater Environment (1977) [16], and Transport of Respiratory Gases during Human Adaptation to Hyperbaria (1988) [46], which were the first in the field of aquanautics among the world’s professional publications. Miraculously, they overcame totalitarian censorship and received recognition from the European Underwater Baromedical Society, Undersea and Hyperbaric Medicine Society (USA) and National Academy of Sciences (Ukraine). Fragments of these studies were repeatedly reported at international congresses [36,39,47-53].

Through many years of research of the functional state of aquanauts, it became possible to develop a technology for the rehabilitation of human health after saturation diving at the depths of the continental shelf. To achieve the necessary results, Prof. S. Gulyar and co-authors continued the high-mountain studies begun by Acad. Prof. Nikolay Sirotinin and his scientific school at the Bogomoletz Institute of Physiology of NASU. Prof. S. Gulyar’s fundamentally new contribution was the experimentally proven possibility of using stepwise adaptation to high-mountain hypobaria and the transformation of physiological mechanisms to accelerate the readaptation and rehabilitation of aquanauts after deep-sea diving. To do this, a series of studies were carried out in the hypobaric pressure chamber of the Elbrus Biomedical Station of the Bogomoletz Institute of Physiology of NASU (Fig. 5), multi-level acclimatization regimes were applied, including the participation of climbers of the Himalayan team [54,55].

Prof. S. Gulyar’s work in the field of hyperbaric physiology was positively evaluated by scientists from the academies of sciences of Ukraine and the USSR. In particular, they were highly appreciated by the director of the Institute, the world-famous physiologist Acad. Prof. Platon Kostyuk. With his assistance, the construction of a specialized physiological barocomplex in Kyiv began.

By the beginning of the 90s, Prof. S. Gulyar had developed a theoretical substantiation of a complex industrial technology for ensuring human performance and safety in underwater conditions. The first approbation of this technology was carried out in the conditions of oil and gas exploration on the Arctic shelf. The technology has been tested on specialized drilling vessels at depths up to 300 m [56,57]. Additional diving technology studies in relation to the conditions of the Baltic Sea were conducted in the 90s in collaboration with colleagues at the Naval Academy Heroes of Westerplatte, Gdynia [39,49-53,116,117] (Fig. 6). Subsequently, professional guidelines and certification documents for underwater medicine were developed.

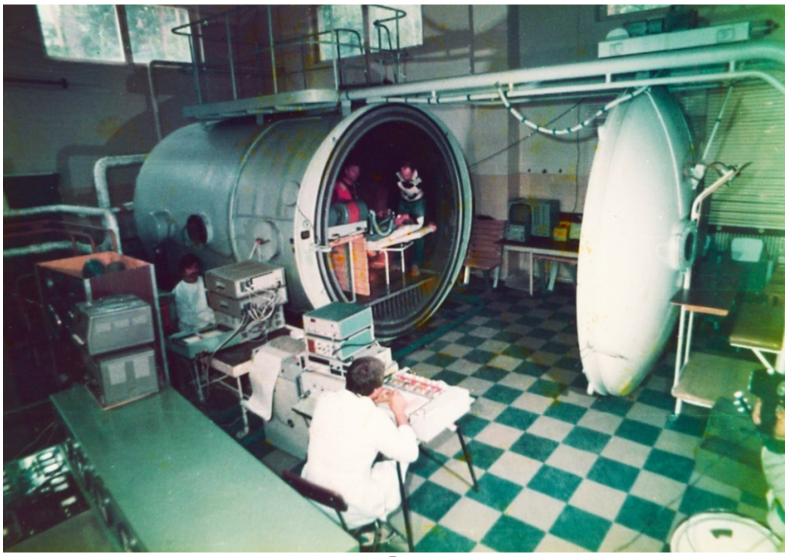
A B

Fig. 6. International scientific group of employees of the Bogomoletz Institute of Physiology at National Academy of Sciences of Ukraine and the Heroes of Westerplatte Polish Naval Academy after joint work at the DGKN-120 barocomplex, Gdynia (1992):
(A) hyperbaric living compartment fragment, (B) employees of the Department of Underwater Physiology and Department o Diving Gear and Underwater Technology at Mechanical and Electrical Faculty (from left to right): inż. Stanisław Poleszak; mgr. inż. Mariusz Wojdowski; Dr. inż. Zbigniew Talaśka; Dr. n. med. Maciej Pachut; Adiunkt Dr. inż. Izydor Kafar; Prof. Dr. hab. n. med. Dr. Roman Olszański and Prof. Dr. hab. inż. Ryszard Kłos; (in the front row): Head of Departmet PhD, DSc, Prof. Sergiy Gulyar; Head of Departmet Dr. inz. Stanisław Skrzynski; PhD, Senior Res. Ass. Vladimir Ilyin.

The relevance of these studies is preserved even today, when the extraction of raw materials for energy on the shelf becomes a vital goal (Fig. 7).

In 1990, the merits of Prof. S. Gulyar in the field of underwater physiology were awarded the State Award of the USSR—the Order of Honor.

A



B

Fig. 7 (A) Acad. Platon Kostyuk, Director of the Bogomoletz Institute of Physiology of NASU, presents the achievements of the Underwater Physiology Department (Prof. S. Gulyar, left) to Vladimir Shcherbytsky, the First Secretary of the Central Committee of the Communist Party of Ukraine; Acad. Boris Paton, President of the NASU; Acad. V. Skok, Head of the Physiology, Biochemistry, and Molecular Biology Branch of NASU and members of the Government of Ukraine (1988); (B) investigations of aquanauts in hypobaric pressure chamber (Elbrus) of the Bogomoletz Institute of Physiology of NASU.

In the last years (1990-s) of the existence of the USSR, Prof. S. Gulyar managed to solve an important organizational problem at the state level. On his initiative and with the assistance of Acad. P. G. Kostyuk, who was at that time the Head of the Division of Physiology of Academy of Science of USSR, an Interdepartmental Commission of the USSR was created to declassify research in the field of underwater physiology. It was a progressive decision, although a belated decision because of the bureaucracy—remember the accident of the “Kursk” submarine, for which Russia did not have neither enough equipment, technologies, nor aquanauts to save it. As we already wrote, in order to hide their incompetence, in the 70s the USSR military department classified research and banned scientific publications on this topic, which caused irreparable damage to the development of the ocean.

The Fourth Stage of Scientific Activity

The "hyperbaric" model was then applied to the study of physiological and pathophysiological syndromes caused by other extreme factors. Since 1996, Prof. S. Gulyar’s attention also has been focused on developing new lines of research related to environmental, marine and Antarctic medicine. He headed the direction of Antarctic Medicine in Ukraine, becoming its first scientific supervisor. At that time, he developed a multi-year program of medical research in Antarctica. As a result of these studies, new unique data were obtained that characterize the physiological changes in the cardiovascular system, mineral balance, individual and group psychology of a person, under the influence of a one-year stay in Antarctica under conditions of solar deprivation [58-60]. In 1998 during the Antarctic expedition Prof. Gulyar personally performed the first 15 underwater scientific dives on the shelf of Antarctica in the waters of the Ukrainian station Akademik Vernadsky (former British Faraday station) and tested on himself the new heat-protective Ukrainian diving wetsuits Katran [61,62].

In 1997-1999 Prof. S. Gulyar developed ways to improve human performance in extreme conditions (aquanauts, polar explorers, climbers) using vitamin and mineral complexes from WindMill (USA). As the general director of the American-Ukrainian Medical Diagnostic Center, he developed methods for in-depth examination of winterers and general strengthening schemes with antioxidant protection. Subsequently, this was tested on the participants of two annual wintering in Antarctica and showed positive results.

Studying the mechanisms of antioxidant protection of deep-sea divers, Prof. S. Gulyar was the first to discover an analogy between the chemical antiperoxide effect of antioxidants on the cell membrane and the biophysical effect of polarized light, which also changes its molecular configuration. These observations prompted Prof. S. Gulyar to the next turn in his professional interests.

Fifth Stage of Scientific Activity

The difficulties of medical support for aquanauts in forced isolation (underwater laboratories, pressure chambers) has been overcome by prof. S. Gulyar due to the introduction of non-contact methods of treatment. He drew attention to the possibilities offered by polychromatic polarized light. Targeted research confirmed their viability. Cooperation with Zepter/Bioptron AG Companies made it possible to carry out research on the effect of polarized light on the physiological systems of the organism and to study the biophysical aspects of this effect. Specifically, in collaboration with Prof. Yu. P. Limansky and Senior Researcher Z. A. Tamarova, the fact of reception of polarized electromagnetic waves of the optical range by acupuncture points, as well as the influence of this radiation and their influence on biologically active zones was explored. The result was the suppression of experimentally induced somatic and visceral pain [63-70] and attenuation of stress-induced responses [71,72]. Polarized light analgesic action was comparable to the analgesic effects of pharmacological drugs in moderate doses [73]. Studies have shown that non-invasive transdermal light therapy combined with chemical analgesics can reduce the dosage of pharmacological drugs used to treat pain. The analgetic and anti-stress properties of polarized light depend on its wavelength. Red light (the long-wavelength part of the visible light spectrum) had a significantly greater effect than medium-wavelength green light [72,74-78]. Light therapy for pain has now gained scientific and clinical acceptance, and its place in medical treatment is firmly established [79].

Having analyzed the facts obtained on light analgesia models, Prof. S. Gulyar was able to identify a more comprehensive list of biological effects of polarized light, which substantiated its utility in hyperbaric conditions [39], including for the correction of pain syndromes in early and late decompression disorders.

In 2000-2010, the new concept of Prof. S. Gulyar about the presence of a functional system of electromagnetic regulation of the organism was further developed [80-83]. According to this concept, polychromatic polarized light can be effective for ensuring the electromagnetic balance of the organism and non-contact treatment of inflammatory and pain syndromes, correction of disorders of the immune system, nervous system, injuries and skin diseases, various electromagnetic imbalances in the organism etc. This approach still has certain knowledge gaps that have yet to be filled.

The National Academy of Postgraduate Education and the Kharkiv Medical Academy of Postgraduate Education of the Ministry of Health of Ukraine have provided significant clinical experience, which allowed the development of targeted therapies by Bioptron devices light and obtaining numerous evidence of their effectiveness [84, 85]. In addition, Bioptron Light Therapy has shown positive results in people exposed to scuba diving, radiation and other adverse conditions. Studying the pathophysiology of hyperbaria and electromagnetic deprivation, Prof. S. Gulyar managed to reveal the common features of both states [15,86-88]. As a result, the theoretical development was successfully introduced into clinical practice to compensate for

The Sixth Stage of Scientific Activity

In the 2000s, Prof. S. Gulyar continued his scientific work at the Bogomoletz Institute of Physiology of NASU. as a leading researcher at the Department of General and Molecular Pathophysiology (Head: Acad. Prof. Aleksey Moybenko). In the same years he initiated joint research at the Institute and Zepter/Bioptron Companies for the development and implementation of new medical lighting technologies (Fig. 8). He created the International Medical Innovation Center, which conducts biomedical research and implements its results. Patents [89-92] and monographs testify to the novelty and relevance of the development of new technologies [16,24,37,46,65,74, 84,85,93-97].

In 2015, after the creation of new LED (light-emitting diode) devices, the development of light therapy technology reached a new level. In particular, with the participation of Prof. S. Gulyar, new medical mobile devices based on red, blue and infrared LEDs—Medolight monochromatic devices—were created [77,98-101]. Their latest generation (Medolight-polychrome) has expanded the possibilities of their application to almost the full spectrum inherent in sunlight. In new devices, it became possible to create various combinations of frequencies and wave ranges (in the presence of effective power) both in an arbitrary configuration and in the form of targeted programs for the correction of specific diseases, which is in process of getting the International Patent [92].

A

B

Fig. 8 Mr. Philip Zepter, president of Zepter International Company, Prof. Sergiy Gulyar, and Prof. Djuro Koruga (A, from right to left) analyze the prospects for developing Bioptron devices for light therapy (B) (2017).

Cooperation with Professor of the University of Belgrade Djuro Koruga, who proposed a hypothesis about the conversion of light by the fullerene molecule (C60) and the possibility of using it for medical purposes [102, 103], determined a new direction of research by Prof. S. Gulyar. As a result, Prof. S. Gulyar and colleagues obtained new data on the presence of positive biological effects of "fullerene" light in animals and humans. In particular, they showed that polarized light converted by fullerene in Bioptron devices, which has a toroidal structure, or scattered light passing through the filters of Tesla HyperLight Eyewear glasses, caused physiological effects. A significant decrease of inflammatory pain and an increase in sleep duration were shown in mice. Many months of exposure of animals under fullerene lighting revealed a slowdown in the development of some signs of aging.

Using electroencephalographic approach (EEG), it was shown that under normal conditions, light converted by fullerene facilitates the performance of visual-motor tests in humans. With a long-term corrective load, fullerene light increases the speed of information processing in the visual analyzer, increases attention and reduces fatigue. The quality of performance of intensive mental load increases. Also, the EEG of the human brain showed an increase in the speed of interhemispheric information processes and an increase in the quality and efficiency of decisions made (according to the data of sensorimotor reactions) under the action of fullerene light when simulating driver blindness [104-111]. All this opens up the options of using fullerene light for medical purposes and in everyday life, as well as a deeper study of its mechanisms and possibilities.

THE SEVENTH STAGE OF SCIENTIFIC ACTIVITY

Remaining an enthusiast of studying the influence of extreme factors on the human organism, in 2000-2007 Prof. S. Gulyar took part in eight historical expeditions as the head of the scientific program, on copies of ancient Slavic oar boats under the leadership of Captain S. A. Voronov (Fig. 9). The ancient routes: "From the Varangians to the Greeks" (St. Petersburg-Istanbul), "The path of Ukrainian Cossacks resettled by Queen Catherine II from Ukraine to Taman" (Dnipro-Kuban), "The Great Silk Road" (Dnipro-Don-Volga) and "Amber Way" (Dnipro-Bug-Vistula-Baltic Sea-Neman) [112-115]. During the expeditions, medical and environmental studies were carried out, which revealed the features of the adaptive reactions of the organism, as well as the scale of environmental water pollution, including radiation [116,117]. Human psychology in extreme conditions, the mechanisms of behavior of members of small groups, and how to correct their psychological climate have been constant research topics in expeditions [58-60].

Fig. 9 Ancient Slavic boat Svarog (Ukraine) (A) and its crew (B) on the route "The Great Silk Road" (2000-2003);
(C) members of the expeditions after the meeting with Mr. L. Kuchma, President of Ukraine; Mr. V. Yushchenko, Prime Minister; Mr. S. Voronov, Captain; Prof. S. Gulyar, Research Head; Mr. V. Tsybukh, Minister of Culture and Tourism of Ukraine (2000).

In 2006-2008 Prof. S. Gulyar took part in a unique Ukrainian-American archaeological program. During the underwater expeditions led by Captain R. Ballard, searches were carried out for sunken objects of different eras in the southwestern regions of the Crimean shelf (Fig. 10). During a successful underwater search with the participation of the scientific vessel Endeavor (USA), the underwater robot Hercules (USA) and the scientific vessel Nautilus-1 (Ukraine), more than 400 unknown underwater objects from different eras were discovered, in particular, a Byzantine vessel with amphoras [118,119].

At present, Prof. S. Gulyar continues his scientific work at the Bogomoletz Institute of Physiology of NASU as a leading researcher of the Department of Sensory Signaling (Head: Prof. N.V. Voytenko). New data have been gathered about the transcutaneous effects of light on inflammatory pain syndromes and stress. Prof. S. Gulyar has verified and refined the previously obtained physiological patterns and mechanisms of reactions to physical factors ranging from hyperbaria to fluctuations in the wave ranges of light and their power [17,72,77,78,110,120].

A B

Fig. 10 After a successful underwater search and discovery of an ancient Greek vessel on the Black Sea shelf (Ukraine, Crimea) (2008):
(A) Members of the US-Ukrainian expedition with the President of Ukraine Mr. Victor Yushchenko (in the center) and the head of the US expedition Prof. Robert Ballard* (right), Captain Sergiy Voronov (on the right), Prof. Sergiy Gulyar (second from left); (B) a fragment of work on lifting amphoras from a depth of 120 m.
*Prof. Robert Duane Ballard, US Navy Captain, oceanographer, eminent researcher in exploration the deep sea using of underwater robots, discoverer of the sinking places of the Titanic, the battleship Bismarck, the aircraft carrier USS Yorktown and many other underwater historical objects.

RECOGNITION OF PROF. S. GULYAR CONTRIBUTION IN THE DEVELOPMENT OF MEDICINE AND PHYSIOLOGY

With more than 150 scientific expeditions and 57 years of experience as an experimenter, Prof. S. Gulyar has accumulated a huge scientific baggage, which he summarized in 470 publications, speeches at numerous professional congresses in Ukraine and abroad, in 20 monographs and 11 inventions. He is the founder of the Longevity High Technologies book series, which includes 12 titles.

Prof. S. Gulyar is a full member of the UHMS (American Underwater Hyperbaric Medicine Society), the EUBS (European Underwater Baromedical Society), the Academy of Technological Sciences of Ukraine, the Academy of Informatics of Ukraine, a member of specialized scientific councils for the defense of doctoral dissertations, a member of the physiological, pathophysiological and physiotherapeutic societies of Ukraine, member of the editorial boards of the international journals Polish Hyperbaric Research and Journal of Health Sciences of Radom University (Poland), the Journal Energy of Innovations (Ukraine), vice-president of the Underwater Sports Federation of Ukraine.

Activities of Prof. S. Gulyar have been worthily marked by international professional societies, the President of Ukraine and the Orthodox Church. Recognition of services to the world scientific community and Ukraine was expressed by awarding the merits of Prof. S. Gulyar in the field of underwater physiology the Order of Honor (1990, USSR), the Zetterstorm Medal of the European Underwater Baromedical Society (1998, Sweden), the Honorary Diploma of the President (2001, Ukraine), the Honorary Diploma of the NASU (2003, Ukraine), the Medal of the President of Ukraine (2008), the Order of the Archangel Michael (2001, Ukraine) and the Order of Cossack Glory (2003, Ukraine).

During his scientific career, Prof. S. Gulyar went through a thorny path, on which he had to overcome constant physical overload, misunderstanding of his colleagues and administrative opposition, including the problems of secrecy in a totalitarian country. Prof. S. Gulyar never lost heart, with honor coming out of trials and enthusiastically eliminated problems that hindered progress in areas that were not easy to master. Not all of his plans came true, but there are still many years of fruitful work ahead—much of what he planned is still waiting in the wings [121,122].

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