UDC 004:591.5:612:616-006 https://doi.org/10.15407/biotech12.02.005

ELECTRONIC AUTOMATED WORK PLACES FOR BIOTECHNOLOGY

O. M. KLYUCHKO[1], *A. A. ARALOVA*[2], *N. I. ARALOVA*[2]

[1]Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the National Academy of Sciences of Ukraine, Kyiv
[2]Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine, Kyiv

E-mail: kelenaXX@ukr.net

Received 28.02.2019
Revised 12.04.2019
Accepted 10.05.2019

The purpose of the work was to analyze data about the construction of electronic automated work places for organization of more perfect ones for biotechnology. Methods of program and mathematic simulation, imitation modeling were used for these works. The information about some prototypes of electronic automated work places constructed for biology and linked sciences in Ukraine during the last 25–30 years was discussed. The results of some automated work places constructed by the authors were presented. In conclusion the observed experience was summarized and the set of recommendations for its practical implementation were done.

Key words: electronic automated work places, bioinformatics, electronic information systems, databases.

High level of the works in contemporary biotechnology needs well developed electronic automated work places with the use of modern technical and computer means, software tools, wide spectrum of others information computer technologies. Increasingly widespread use of information and computer technologies (ICT) in all medical and biological sciences — and first of all in biotechnology — characterized the last 25–30 years [1–11]. ICTs for biotechnology were developed rapidly in directions of the latest devices, hardware, apparatus and programming complexes construction, as well as development of software specialized for biotechnological tasks solution. However, medical and biological objects are characterized by their peculiarities, which determine the complexity of ICT use in medical and biological industries. These peculiarities are [1]: 1 — complexity of medical and biological objects; 2 — their multicomponents characteristics; 3 — presence of numerous connections between biological objects and their elements; 4 — stochastic interactions and characteristics of processes, and etc. [1–11]. Consequently, there are appeared some difficulties, as a result of which the use of ICT here demonstrates a certain lag in comparison with physics, mathematics, and technology [1].

However, the leading Ukrainian scientists started ICT use in medical and biological industries in the XX century. Kyiv scientists from the National Academy of Sciences of Ukraine have made significant progress in those years. The ICT use in biological fields and medicine was initiated by academicians Amosov N. M., Glushkov V. M., Kostiuk P. G. and representatives of their scientific schools (Shkabara E. A., Pyatigorsky B. Ya. and many others). Today, basing on modern ICT level, these approaches are developed fruitfully by their successors, modern representatives of their schools; a wide ranges of such methods are represented also in the most developed industrial countries of the world. Ukrainian scientists began their works on the construction of "automated workplaces" for scientists working in research institutes of the National Academy of Sciences of Ukraine in early 1980s. Their aim was to facilitate the work of researchers at the level of developed computer technologies, to ensure the reproducibility of scientific results, to improve the exchange of digital information between employees and various scientific groups, to make research work more intensive, and etc. These tasks' solutions were achieved through the development of "automated workplaces" (AWP), specialized for various scientific tasks' solutions, and the best at that time specialists and advanced computer technologies were involved. Over time, along with the specified term AWP, the definition of "electronic", indicating the nature of the developments began to add increasingly; so in this publication we have used the generic term "electronic automated workplaces" (EARM), which we use along with its synonyms "electronic workplaces" (EWP) and "automated workplaces" (AWPs).

In reality EAWP are the elements of ISs that were designed either for academic purposes — to maximize the accumulation of information about the groups of living organisms, or for the needs of the economy, in particular for biotechnology, for monitoring of polluted areas in industrial centers, and etc. [1–9]. Mathematic background of EAWP as well as models that we described in our previous articles and published by other authors also may be used for ISs functioning or to be simulated in result of their functioning [9–81]. A spectrum of mathematic methods were used for the newest biomedical ISs elaboration [1, 11, 75, 77–146, 159]. Content for described in this article databases was obtained usually from the results of biological and medical observations and experiments [10, 12–17, 24–44, 47–49, 61, 68, 71–74, 82–90, 94, 104, 106, 109, 111–113, 125–159]. All such technical information systems (tIS) are electronic databases (DB) distributed in networks today [1–11, 25–69, 90–109, 112–120, 159–179]. Present work was done after the analyzis of approximately 250 current publications in fields of biotechnology, other branches of biology and technology, including articles with original authors' works. Obtained results were supplemented also by the author's patents [12, 164–179].

The first automated electrophysiological experiment and domestic electronic workplaces in biophysical research. Works in the direction of an automated electrophysiological (biophysical) experiment carrying out and the first perfect electronic work places were constructed at Bogomoletz Institute of Physiology NAS of Ukraine on early 1980s. These works were carried out under the leadership of Prof; Dr. Pyatigorsky B. Ya. with collective of authors — Drs. Zaytman G. A., Cherkassky V. L., Chinarov V. A., others; their results were described in details in their monography [11]. The actuality and high level of these Institute works supported the most advanced at that time studies of nerve cells' biophysics, their membranes, cardiovascular and bone-muscles' systems, higher nervous activity, the action of wide spectrum of substances of natural and artificial origin on living organisms, and etc. In [11] it was noted that the experimenters in these fields faced the problems related to various fields of computing and measuring technologies, programming, processing of experimental results. Consequently, this group of developers has fulfilled the task of EARM construction successfully. The technical equipment of for automated experiments (AE) was described in [11]. The characteristic features of electrophysiological complex of devices (ECD) used for AE conducting were described; also there were described organization, construction principles and specific examples of devices for communication computer-experimental object, as well as general organization and architecture of computers used for carrying out electrophysiological experiments in the specialized institutes of the highest level in the Soviet Union at that time.

Simultaneously with the development of devices and hardware, the relevant new directions of mathematical and software methods for AE systems were developed and improved [11]. The authors described examples of their AWP construction in accordance with the specific system of guided experiment to study the role of microstructured sequence of potentials in processes of nerve cells' information transmission. The process of their technical system constructing was presented sequentially from profound problem statement up to configuration definition of technical means and software.

The authors described the process of their electrophysiological experiment with developed AWP, and at the end they gave the results of automated experiments on the imitation model of living object. The beginning of the experiment was standard; the exception was only a thorough check of system's functionality before the start of experiment, testing the system as a whole and at the level of individual modules. Such beginning was due to the fact that after the start of experiment (start of the system functioning), the experimenter actually only observed the operation of the system and, if necessary, could stop it to change some parameters. He did not have a time to execute any complicated changes in computer program. Consequently, AE carried out with developed AWP, required more precise planning before it was started, since serious modifications could not be made during the experiment.

Most of physiological research ends usually with the phenomenological description of the subsystem under investigation; and in some cases it is possible to create mathematical or imitation models that describe in abstract form the basic properties of studied biological objects and processes in them. About the simulation in biological experiments we already have written in details before [1, 7]. Mathematical and program models give researchers number of benefits, we would like to mention only the following. If later it was discovered that the main assumptions were not correct, then it was necessary to return to the beginning of the task (or to the beginning of experiment). To speak about adequacy of a model it was possible only when: 1 — the coherence between its properties and the results of experiments was obtained; 2 —it was possible to predict the behavior of physiological subsystem, and then 3 — these predictions could be verified experimentally on a real object. In most cases, the research on the models of biological systems it was necessary to carry out with the help of computer technologies, since their analytical research is impossible. In our numerical previous publications [1–6, 18–37, 61, 62, 64–66, 75, 126–148] we have investigated repeatedly the various aspects of phenomena and processes described in this publication.

Usually such models in most cases (even in mid 1980th) could not be built on the basis of a local computer only. And even in those years for this purpose there were constructed computer complexes, combined with the related inter-machine communications. In our time, such EARM are implemented in the forms of computer complexes combination in local area networks with their further access to the Internet. Below we will provide information on similar EARM analogues.

Analysis of current needs of biologists, some medical doctors in information and requirements for its receipt. Information support systems for biologists of different specialties have to be constructed on the basis of their daily needs in following data sets. For example, biologist who study hypoxia problems needs following information:

1) the most up-to-date data in framework of investigated problem;

2) if necessary — basic theoretical information in framework of investigated problem and related problems (theoretical, methodological, historical, etc.);

3) information about the substances used (their properties, new synthesized substances, prices for them, etc.);

4) information about new equipment;

5) publications on new, newly patented methods, devices and other patent information.

Only the most important types of information needed by scientist for daily work are listed above. In addition to the abovementioned, lets give a list of some additional types of information needed by scientist who studies hypoxia problems:

1) information about upcoming conferences, scientific meetings;

2) information about grants, different competitions of scientific works, etc.;

3) information on the possibilities of scientific works' publishing, the rules of publication in various editions, etc.;

4) the databases of the own data obtained during the current experiments (Tables 1, 2).

Requirements of specialist of medical-biological sphere to the process of scientific information obtaining. The process of modern scientific information obtaining by scientist has to be characterized by:

1) high speed (preferably — instantaneous reception of information);

2) the widest range of the data that would be desirable to receive, the greater amount of the data);

3) the selectivity of received information and the selection of necessary data from a huge amount of unnecessary one.

Computerization of the scientists' activities, construction of computer networks, Internet capabilities provide the first and second ones — the amount of the data and the speed of their receipt. Concerning the third one — the information selectivity, the authors decided to help biologists in the rapid information search, picking them such databases set, which would satisfy a wide range of the most general needs, contributed to increasing the efficiency of their work.

AWP for the examination of organism adaptation characteristics. With the beginning of 2000, the idea of automating research and computerization was upraised to a new hardware and software level and it has become extremely widespread due to its powerful capabilities and the new level of ICT development. In current few subchapters we will demonstrate how the idea of EAWP was implemented by Ukrainian cyberneticists worked in the field of biological research. The results of AWP elaboration described in following five subchapters were obtained by Aralova A. A., and Aralova N. I. from Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine for the training works in aviation of pilots, other members of flight crews.

An information system is proposed for the examination of flight crew members' functional states; the system is based on the concept of human's organism's oxygen regimes control. It was implemented on the base of the database managing system and the Lasaru programming system. This electronic information system includes two automated work place (Fig. 1) The list of their functions and functions' descriptions were described as well. These automatic work places allow providing of significant practical support in solving of set of tasks that are linked with improvement of organism state, development of the general physical qualities and the special physical training of flight crews' members.

Studying the dynamics of aviators functional state in process of their professional activity with the help of physiological research methods allows with a high degree of reliability to estimate their organisms' potential capabilities and to diagnose changes in the functional state under the influence of various factors and loads, both different according to their complexity and degree of influence.

Flight work is going in special conditions that differ significantly from other types of professional activity. During the flight, the pilot's body is under the influence of complex set of factors of changed environment, acceleration and overload, differences in barometric pressure and temperature, rocking, noise, vibration. Also, considerable inconveniences during the work are the results of pose stiffness, flying suit and special equipment, the need to use oxygen-respiratory equipment. Unlike other professions linked with the management of complex machines and aggregates, the pilot interacts with two dynamic systems simultaneously: he controls the work of engines and aircraft mechanisms and performes the movement of the aircraft in a three-dimensional space. Under these conditions he must perform a large number of generalization operations during the short time intervals of information flows from the numerous indicators of airplane and equipment management.

The pronounced organism reaction on adverse factors of flight work influence is determined by the strength and length of the action. Besides of this, the response-reaction will be determined by the complex influence of the initial organism functional state and its reactivity that depends on many conditions of the internal and external environment, state of organism health, ability to distribute properly their forces for the entire time of work, the ability to apply correctly breathing techniques and techniques of protective muscle tension, as well as the concomitant effects of other extreme environmental factors and flights. Responses-reactions of organism can have both adaptive type, as well as to reflect cumulative damaging effects of extreme loadings.

Overloadings on modern aircraft are characte-rized by the significant numbers (up to 9 units) and, this is the most important, by a high speed of their increase (up to 5–7 units/s), which reduces their portability, and requires the implementation of measures for

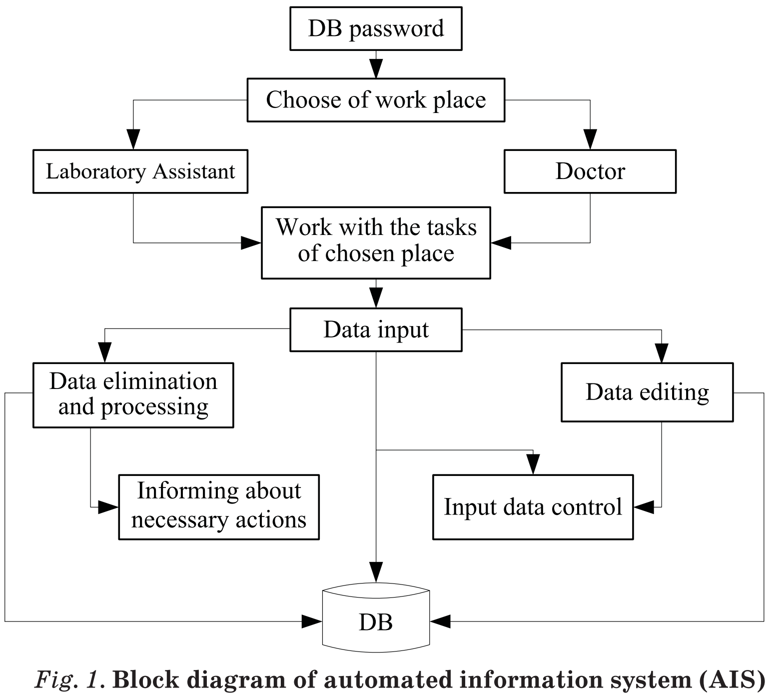

Fig. 1. **Block diagram of automated information system (AIS)**

the special training of pilots. Thereby, the actuality of researches aimed on the studying of tolerance to aerodynamic overloads by pilots who flights on manoeuvrable aircrafts and the development of methods for resistance increasing to these effects, especially after breaks, is currently increasing.

The estimation of functional capabilities and the degree of physical pilot fitness to the influence of aerodynamic overloads is carried out currently when performing a staggerometric test, which is based on the creation of static muscular efforts.

In some investigations based on the methods of the theory of reliability, a model of reliability of the functional state of operators of the system of continuous interaction, which also includes persons of flight crews (in the form of a chain with a "weak link"), is proposed. There also were grounded that the "weak links" of pilots are the respiratory system and system of psycho-physiological functions. So, it is obvious that when performing the staggerometric test there is a need to inspect the respiratory functional system, which provides the pilots ability to perform the set of training and combat tasks. It is clear that such an examination involves the need to process and accumulate the large volumes of information, which needs to be processed, stored, compared and analyzed thus, it is necessary to develop the appropriate mathematical, algorithmic and software means. The purpose of work done was to create an automated information system for diagnosing a pilots' functional respiratory system.

This system would allow to:

– implement a diagnostic algorithm for the estimation of functional status of flight crew members;

– accelerate repeatedly processing of the data obtained during pilots inspection;

– accumulate in centralized manner the information for its pre-processing, storage and collective use;

– develop an algorithmic device for providing of the opportunity to prove scientific hypotheses, to develop options for optimization of decisions when assessing the professional suitability of flight crew members.

Organism's oxygen regimens and their regulation. At present, one of the most effective and relatively simple methods to obtain the information about the respiratory system functional state is the estimation of organism's oxygen regime (OOR) and the phased oxygen delivery to human body. This method is based on the concept about the regulation of organism's oxygen regimes, according to which there are two linked groups of parameters of oxygen transport speed and its partial pressure and pressure at the main stages of its path in human body (lungs, alveoli, arterial blood, mixed venous blood). Analysis of these two groups of parameters combination allows us to characterize the function of body's system of oxygen supply both quantitatively and qualitatively.

This approach allows us to obtain general characteristics of gas homeostasis with a minimum of indicators, to give it detailed analysis involving the fundamental mechanisms that provide the transport of respiratory gases, to carry out the diagnosis of the main syndromes associated with disruptions of the gas transportation function, to give the oxygen "portrait" of the organism and its dynamics at various functional states, to estimate the organism ability to recover itself from external and internal disturbances. The systematic accumulation of these data, their systematization and subsequent processing and analysis provide the possibility of recognition and objectivity of characteristics of large number of flight crews' personnel, which are examined. All this makes possible to follow the changes in dynamics of key indicators in process of general physical training of pilots, which contributes to the recovery and improvement of organism and the development of general physical qualities and special physical training, which is professionally oriented and directed primarily to increase the body's resistance to overloads that are happening during flights. Special physical training develops and improves physical qualities such as muscular strength and static muscular strength, which are professionally important for pilots of maneuverable aviation.

Structural scheme of information system. With the development of the use of mathematical apparatus and capabilities of modern computer technologies to improve the means and methods of operational collection, processing and analysis of the data from a complex study of flight personnel on the basis of database managing system (DBMS) and Lasarus programming system, an information system (IS) was developed and implemented, its block diagram is presented on Fig. 1. Information system allows: to accelerate processing of the data obtained during inspection of pilots; to implement diagnostic algorithm for assessing of the functional state of flight crews' members; to centralize the accumulation of information for its pre-processing, storage and collective use; to develop an algorithmic device for providing of the opportunity to prove scientific hypothesis, to develop options for decisions optimizing during estimation of professional suitability of flight crews' members.

In the database (DB), which is a part of IS, the information about each person who has undergone the examination is collected, including questionnaire data, hours of exposure, data on special technical and physical state, and the results of comprehensive survey that is performed for the estimation of respiratory system.

Since IS organization suppose the data structure that reflects the various diverse pilots' characteristics, its development has become a prerequisite for the solution of many tasks related to the estimation of flight personnel professional adaptation. Accumulation of structured information in the database provides effective means for:

– collective use of information in a mode with many users (multi-users mode);

– obtaining of enquiry on all information arrays or on individual fragments, including an arbitrary set of conditions that is defined by the user;

– constructing of series of indicators values from DB structure and their transfer for statistical processing of results;

– automation of evaluation process of the results of testing with the subsequent integration of indicators of different aspects of pilots preparedness;

– formation of output documents, tables, graphs, reports, histograms for different categories of users;

– conducting a retrospective analysis of the training of flight crews' members who have achieved significant results in special training for generalizing of psychological, physiological, sociological factors, experience of initial basic training, which provided the background and improvement of flying skills.

During the development of the IS, two automated work places (AWP) were provided — "Doctor" and "Laboratory Assistant". This division was due to the fact that data collection during survey requires a set of specific knowledge and skills, while for the recording of initial information, anthropometric studies, blood sampling for analysis, this knowledge did not needed. Besides of this, the blood tests are carried out in the laboratory but not at the workplace. Indicators that characterized the state of the system of external and alveolar respiration, cardiac activity, and blood circulatory system are recorded directly at the workplace and can be input by the Doctor. The block diagram of IS of the Doctor is presented on Fig. 2. The units of the Doctor's AWR are shown on Fig. 2, they perform following functions (Table I).

The algorithm of system functioning. The system functioning algorithm is following. After logging in to the "Laboratory Assistant" AWP, user input general data about examined person: last name, age, qualification, hours of flight, preparation, and etc. The system has the ability to form groups by age, qualification, training, and etc. After that, the examination applications for defined group under the specified condition are being prepared.

On the basis of examination applications, the collection of general data from external environment is carried out (barometric pressure, partial pressure of water vapor, altitude, temperature at environment, and etc.). A blood samples for analysis are also carried out. Further, the "Doctor" examines respiratory system, geodynamics, cardiac activity in a state of the rest and during the loading (veloergometric load possible, step-test, statoergometric test), depending on the purpose of survey. When all necessary data for the calculation are input, the program calculates the organism's oxygen regimes and distributes them in groups according to different parts of respiratory system. Also, the indicators that characterize velocity, intensity of the phased oxygen delivery as well as indicators characterizing the efficiency of respiratory system and blood flows, parameters that characterize the hypoxic state of the organism are determined. Transactions within the framework of one application can be performed multiple times.

Information system software. Block diagram of IS software is presented on Fig. 3. Such software distribution allows performing the functions assigned to it optimally. Let's describe the functions, internal and external data of individual units in details.

Initial data input unit. Provides the correct input of the data about the examined personnel group, the state of groups' organisms at different moments of examination, it includes also verification of the data compatibility.

Regular data input unit. Provides correct input of general human data-characteristics: name, last name, age, qualification, flying hours, and etc. The results are recorded in the database.

Table 1. **Doctor's AWR Units' Functions**

DBMS	Managing mechanisms, editing and the work with the system data at DB level
Tables, stored procedures, triggers	Instruments for DBMS management that were provided by developers for the optimization of access to the data, in dependence on the tasks that are solved (non-accessible for user)
The work with DB unit	Provides interaction between DBMS and users via above described instruments
Control unit (program)	Provides the calculations, connection with DBMS, fulfillment of users' tasks
Units of work with reports, work on experiments, work with applications, work on analyzes and results, work with contracts, work with clients	Sub-tasks of the AWP, that are fulfilled through interaction with the user via dialog interfaces

Personal data input unit. Provides correct view of anthropometric data, data of laboratory research. The results are recorded in the database and used in current calculations.

Examination data input unit. Ensures the correct input of examination data. The results are recorded in the database.

Incoming data maintenance unit. Provides the data storage in the database. Recording takes place either automatically or according to user directives.

Mathematical solver unit. Constructs and performs calculations.

Result submission unit. Performs graphical and table representation of the results of the work.

Reports maintenance unit. At the request from the user, forms the report about the work done.

Developer info[rmation] unit. Provides an information about developers with the contact data.

HELP unit. Provides contextual help, instructions and advices for user from any task.

Exit from the system unit. Provides correct output, saving of parameters and current data through user dialogue.

The crucial unit is the Main Menu, which is defined by the tasks of the user's AWP. General units for both AWRs are "Help", "Developer info", "Exit" units. In other units

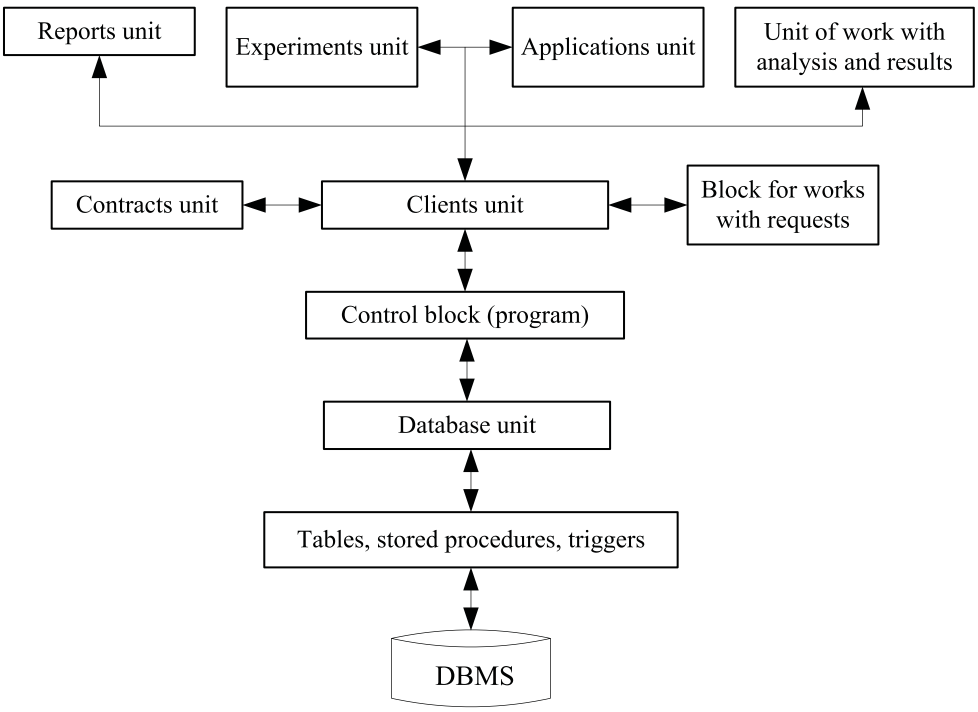

Fig. 2. **Block diagram of automated work place (AWP) "Doctor"**

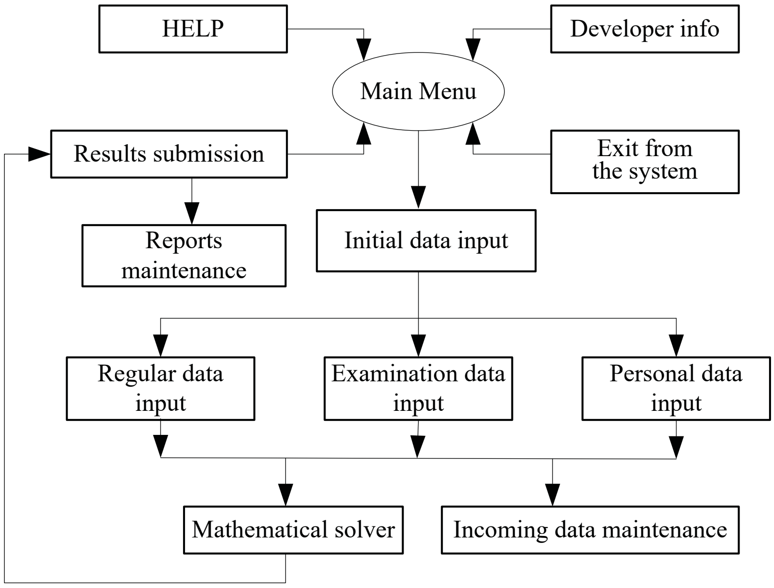

Fig. 3. **Automated information system software scheme**

there are functional divisions depending on the tasks solved by these AWRs. In particular, the "Mathematical solver" unit does not participate in the work of AWR "Laboratory Assistant" and is an exclusive part of AWR "Doctor". "Regular data input" and "Personal data input" are exclusive only for AWP "Laboratory Assistant".

On the other hand, units "Reports maintenance", "Submission of results" and "Initial data input" works in each AWR according to the same principles, but with different data.

Since the AWP are implemented on the basis of the DBMS, this enabled to use such powerful tool as report editor. Thus, based on the data ordered in the database, we can perform a statistical survey and data processing according to different criteria and present the results in documented and normative terms that are available for further processing by standard text editors.

Further development of elements of local information systems with databases for biologists and scientists of different specialties. Computerization of the scientists' activities, construction of computer networks, Internet capabilities provide the amount of the data and the speed of their receipt. Concerning the selectivity of information obtaining, another author, Dr. Klyuchko O. M. decided to help biologists in the rapid information search, finding them such databases set, which would satisfy a wide range of the most general needs, contributed to increasing the efficiency of their work, especially to scientists who carry out experiments (hypoxia studying, works in neurotoxicology, neurophysiology), as well as to biologists who work in ecology, zoology, and etc.). These works also were done in 2000–2003 [1]. In framework of these works she had developed three electronic workplaces — EWP, described below. There are: 1 — EWP-H for biologist who study hypoxia problems; 2 — EWP-Z for zoologist; 3 — EWP-NF for neurophysiologist and biophysics who works in neurophysiology [1].

To provide scientific works for biologists of different specialties Klyuchko O. M. elaborated the series of EWP (EAWP) [1]. Like previous AWP, these works were performed with the use of the Internet and developed linked databases on 2000–2003. Regarding to the latter, these EAWP need the existence of local and remote databases both with the use of network technologies. All three of described below EAWPs were constructed according to one principle. However, the list of functions performed by them consistently increases from the first to the last modifications. Accordingly, the number of EAWPs' functional units was increased from the first EAWP to the last one. For scientists, professors, an access to such IS databases is convenient to organize through EWP, one of the functions of which is the interface function. Below we will observe in details these "workplaces" (WP) for biotechnology, biologists and physicians who work in several industries. It is RM for professionals in the fields: 1 — physiologists who study hypoxia (EWP-H); 2 — ecology and zoology of insects (EWP-Z);

3 — neurotoxicology, neurophysiology, brain biophysics, and other branches related to brain problems and nervous activity (EWP-NF). In details WP common features will be demonstrated on the example of EWP-H — WP for physiologists who study hypoxia.

Differences in structures of all three WPs were determined by specifics of the work in each specialty [1]. 1 — EWP-H is the simplest version; physiologist who works with hypoxia usually processes numbers, texts, tables. 2 — ERM-Z for ecologists and zoologists was more complicated; an additional unit for the work with images added to the basic structure of the previous EWP-H (at that time we have worked with butterflies *Noctuidae* (*Lepidoptera*)). 3 — EWP-NF: another unit was added to the units of the previous EWP-Z, where was recorded an information on various processes in neurophysiology, which were modeled on the basis of received experimental data, including the influence of studied toxins on neurons, a database contains also developed program models. These program models included imitation models, like ones simulated the processes of electrical impulses propagation on the DNA molecule, neurons that were visualized using potential-sensitive molecular markers, and etc. All developed EWPs could be used as part of a large-scale integrated network for environmental eco-monitoring in the vicinity of industrial objects, since such a network should include EWP for professionals of different specialties. Thus, EWP-H could also be used to study hypoxia due to the action of environmentally toxic substances, EWP-Z for eco-monitoring of the state of bioorganisms' populations in places of aviation pollution, EWP-NF — for diagnostics and testing of ecotoxins' effects, and etc.

Specificity of information supply for persons who study of hypoxia problems (EWP-H). Hypoxia, or the state of inadequate oxygen supply of organism tissues, is a common phenomenon [1]. Oxygen deficiency in organism occurs in the environment of conditionally suitable or not suitable for the life: during aviation and space flights, in highlands, underwater environment, as well as in various extreme situations. The state of hypoxia arises in tissues as a result of numerous adverse factors: chemical poisoning, wounds with high blood loss, infectious diseases, tissue compression in accidents or disasters, and others. Therefore, it was necessary to modernize the system of professionals providing with information to meet their current needs. So, the experimenter in this field needs new reagents for daily use, and chemical laboratories provide hundreds of new substances, reagents every day. This necessitated these tasks solution during the elaboration of electronic WP for the daily needs of scientist who work in this area [1].

The structure of the EWP-H system [1]. The structure of this system is defined by the analysis of what data a scientist who works with hypoxia needs in process of his work. The researcher in this field would be most satisfied with such electronic system in his personal computer that would combine two parts: 1) own databases of this researcher (such as, for example, own experimental data and databases containing data important for the researcher needs in reagents, equipment, etc.); 2) — a database containing information from specialized electronic resources, including exits to library and other databases in the world. Such an electronic system was called "Electronic Workplace of Physiologist Working with Hypoxia": EWP-H. The block diagram of the EWP-H was shown on Fig. 4 [1].

The first part of the EWP-H was DB of the scientist (Fig. 4). It was called PDB, or "personal databases" of the scientist who works in the field of studying of organism hypoxic states. It contains various data, with which the specialist works directly and daily. These data would be organized in electronic databases designed specifically for each scientist. Usually there are materials that should always be "handy" and accessible for daily execution. These would be local databases (in our case they were executed in Access, and less often in FoxPro).

The PDB content was grouped into the following components.

1.A — DB, contained articles and abstracts in electronic form. This part differs from one like Internet MLIS; in that it contains only materials of scientist that he picked up from the available resources (primarily through MLIS), or have done by himself (texts of own publications). 1.A was divided accordingly into two databases (on Fig. 4 was not shown): 1.A — printed versions of the articles that the scientist is preparing to publish (usually documents were made in formats.doc or.rtf), and 1.A.B — electronic versions of articles required for other colleagues (usually scientists get them via the Internet from remote library resources, most often they were in format.pdf,.html, rarely -.rtf,.doc)

1.B — DB with chemical substances with which the physiologist professionally works daily. To ground the need in this electronic component, let's study the information

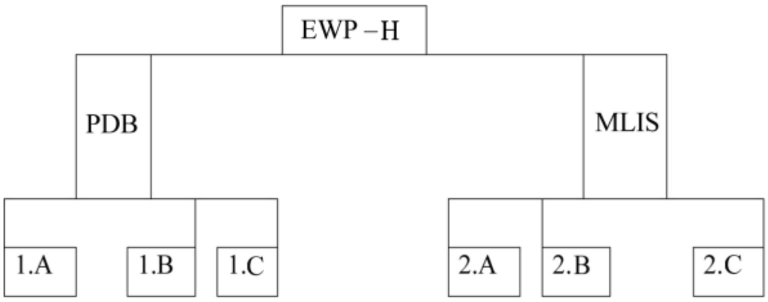

Fig. 4. **The block diagram of electronic workplace for the scientist, who study the effect of hypoxia in extreme conditions (EWP-H):**
PDB — private databases of this scientist; 1.A — electronic versions of publications;1.B — databases with information about substances and reagents; 1.C — DB with own experimental and working data; MLIS — "mini-library Internet — system for physiologists"; 2.A, 2.B, 2.C — its constituent parts [1]

in Table 2, that was made on the basis of daily experiments. Let's analyze the results presented in this table from the point of view of the information that would be useful for scientist to fill his own databases. Substances listed in this table could be divided into two large groups. 1.B.A — the reagents required for the experiment (glucose, proteins, salts, and etc.). Often during the daily work of experimenter it is necessary to know either the molecular weight of the substance, or the concentration of this substance in the physical solution or environment, or the manufacturer and other data. Being organized into convenient local database, they are for the experimenter "always in hands." 1.B.B is the group contained the information about substances that are experimentally studied. For example, in our case, there was splenozid, the influence of which on the various tissues under conditions of hypoxia was studied by experimenters. For the scientist it is also important to know following data: approximate molecular weight, origin, requirements for this substance relative to the pH in the surrounding solution, and etc. So, it is advisable to add these data to the database, especially in situation when physiologist study the effects of dozens of similar pharmacological agents for the selection of potential therapeutic agents and would like to accumulate such data for further analysis.

1.C — DBs containing the information needed for experiments. There are several types of these databases too. 1.C.A — there were DB, containing protocols of standard conditions for conducting experiments. As often these conditions have to be selected, it is better to remember these data of the main successful working variants. 1.C.B — digital data of experiments (with minimal processing and without analysis). 1.C.C — processed and analyzed data in the form of graphs or tables. On the basis of these materials, one of the databases in 2.A was formed — where the articles prepared by scientist were transferred.

The second part of the EWP-H. The second part of EWP-H also was performed on 2000–2001 in Bogomoletz Institute of Physiology of the National Academy of Sciences of Ukraine. It was called MLIP (mini-librarian Internet system for physiologists), and it was elaborated taking into account the requests of colleagues-scientists. There the system passed the first tests and was recognized by the scientists as convenient and useful. Brief information about the MLIS by the author has already been published [1], let's describe it in more details.

Brief description of the second component of the EWP-H. The second component of the EWP-H called MLIS. It should be noted that MLIS serves as a service element subordinated to the PDB.

In general, it was a system of Internet-pages connected by hyperlinks; so, it is an Internet site with databases. The system had convenient and rational organization making it easy to use. The system was created in.html format with the help of Frontpage. With the help of MLIS, researchers obtained access to wide range of medical and biological periodicals already selected for them (the last today information resources as well as resources with fundamental data). The scientists received all the information free of charge, including full text articles in.pdf format, with the exception of two remote library databases, which provided free access only to the abstracts.

The system center formed two pages. The first was a page with a map of access to all electronic resources that user goes through the MLIS. This page was friendly designed and contained minimum of text. The design was

Table 2. **The state of glutathione system and activity of glucose-6-phosphate dehydrogenase in rat tissues during blood loss and after the influence of splenozid**

Parameter	№	Control	Blood loss	Blood loss + + splenozid influence
GSH, μmol / mg protein	1 2 3	2.90 ± 0.02 1,93 ± 0.01 2.10 ± 0.06	1.72 ± 0.02* 0.93 ± 0.02* 0.70 ± 0.01*	2.75 ± 0.01** 1.63 ± 0.01** 1.18 ± 0.03*
GR, nmolNADPH/min/mg protein	1 2 3	23.18 ± 0.24 10.32 ± 0.15 11.40 ± 0.12	11.77 ± 0.14 * 8.11 ± 0.10 * 4.85 ± 0.15 *	16.42 ± 0.12** 10.04 ± 0.18** 9.20 ± 0.12 **
GPx, μmol GSH/Mg protein	1 2 3	5.53 ± 0.06 6.42 ± 0.02 4.87 ± 0.03	5.21 ± 0.01 4.57 ± 0.04* 2.20 ± 0.01*	6.65 ± 0.20** 6.90 ± 0.04** 2.64 ± 0.01*
G6PDH, nmolNADPH/min/mg protein	1 2 3	16.00 ± 1.8 8.53 ± 1.0 10.60 ± 1.2	18.09 ± 1.2 * 9.95 ± 1.4* 11.99 ± 2.1*	28.06 ± 1.9** 17.70 ± 2.0** 13.08 ± 1.2**

Note. The averaged values are ± SEM for 10 rats: GSH — recovered glutathione; GR — glutathione reductase; GPx — glutathione peroxidase; G6PDH — glucose-6-phosphate dehydrogenase. Each parameter was given for the liver, heart, brain. Reliability was expressed as: * — $P < 0.05$ in comparison with control; ** — $P < 0.05$ between experimental groups ("blood loss" and "blood loss + splenozid influense") (*t*-Student test) [1, 138, 149]

executed in the form of bright squares, which provided links to several database groups, which can be used by scientist-physiologist. The author identified three main such groups; according to this page one could easily go to each of three types of databases. The second central page was an analogue of the first, in fact, it is completely symmetric. Its difference from the previous one was that the page is completely text-based; the text is divided into semantic blocks. Each of the three semantic blocks had complete information on the three main types of databases available to scientist through MLIS. Like the first one, this page also helped to access easily the three above-mentioned databases. Let's observe briefly each of the three major groups of electronic resources, of which scientists could receive professional information on 2001–2002.

2.A. This database contained lists of biomedical and biophysical journals of great need of physiologists. These were scientific journals from different countries of the world, to electronic versions of which for advertising purposes, sometimes owners provide access through the Internet. This list was constantly updated, since access to such journals "opens" and "closes" periodically. Through this page, the user was free to go to reading full-text electronic versions of these journals. The list of such journals for scientists of the Institute was about 100 for 2001. According to the developer, such number could largely meet the needs of the scientists. With this page, physiologist could easily, without spending time to search, to view and work with a large number of journals he needs.

2.B. This database contained information in forms of electronic versions of full texts of articles from three physiological journals, which were in greatest demand of physiologists. Such journals' DB was recorded and organized by the author in computers' memory in Institute library on 1998–2000. According to the system's pages, scientists could find out the list of electronic journals in Institute DBs, as well as their content. Scientists also got an opportunity to find abstracts of articles and their full texts on a separate channel.

2.C. Elaboration of the third type of database became possible due to the fact that the Bogomoletz Institute of Physiology of the National Academy of Sciences of Ukraine participated in three major information projects: Academic Press, EBSCO and Springer on 2000–2002. During 1.5 years the scientists were able to read freely in the Internet electronic versions of full-text articles of the professional periodicals of known world resources that were obtained by the author and organized in the database of the Institute's electronic library. The structure of the system had the possibility of its further development. During 2001–2002 the system met the needs of physiologists in scientific information adequately. For six months of constant recourse to it, only four orders could not be satisfied, because there were requests of rather rare editions in a very narrow area of research.

Thus, physiologists have described MLIS as useful in work, effective and easy to use [1].

EWP for ecologists and zoologists (ERM-Z). According to similar principles, WP was developed for researcher-ecologist and zoologist who work with invertebrates — EWP-Z [148, 196, 197, 207]. Block scheme of EWP-Z was shown on Fig. 5. EWP-Z was originally developed to study the adaptation of insects in the highlands of the Elbrus region (Caucasus, Russia) of such journals. This system could also be used by researchers studying the effect of extreme conditions on bioorganisms. Because of the importance of such data, the monitoring databases were subsequently formed for the solution of environmental problems, then EWP-Z is desirable tool also for ecologists who use insect observations for analysis of environment state. This WP was similar to previous one, although it had its own specific differences. The main difference was that the images of insects — in our case butterflies, *Noctuidae* — are the necessary part of such databases. *Noctuidae* images were needed to make database for the development of electronic identifiers of insects, expert systems that must determine the type of pest, and etc. Since image operations were important for the operations of such systems, such methods were discussed in our previous publication [6].

Requirements of zoologists to electronic WP. Let's consider what requirements has zoologist to the contents of material in electronic IS. Unlike the researcher who studied hypoxia and who uses mostly biochemical techniques, zoologist often recorded in the databases the results of field observations, species definitions and their digital characteristics. Sure, zoologist also had possibility to record in EWP-Z information on chemical and biochemical substances. In addition, in EWP-Z it is necessary to insert a component for recording and processing of image objects [1].

The structure of the EWP-Z system is shown on Fig. 5. Like EWP-H, it united two parts. Part I — oven database of researcher-zoologist: PDB-Z (DB with observation data, results of definitions, database on reagents or other substances (pheromones, etc.) as well as database with images and database with observation films). Part II — with library information of profile electronic resources, including links to library and other databases of the world (analogous to MLIS above but its collection of electronic materials directed to requests of the zoologist). The element of the circuit 1.G has fundamental differences from the similar for the EWP-H, it contains digitized images of *Noctuidae* and parts of their organisms.

EWP for scientists in the field of neurotoxicology, neurophysiology (EWP-NF). WP for researcher in the fields of neurotoxicology, neurophysiology was designed according to the same principles. But EWP-NF differs from EWP-H, because there it related to the specifics of the tasks to be solved in other branches. The neurophysiologists carry out electrophysiological experiments [12, 13, 15]. For the neurophysiologist important information about both the substances and the data obtained during electrophysiological experiment — digitized records of electrical signals — responses to the action of chemical substances or electrical stimulated impulses. These results were recorded in our elaborated DB of EWP-NF.

The structure of the EWP-NF system. EWP-NF structure was similar to the previous EWP-H and EWP-Z. The difference was only in the data for the DB EWP-NF and, respectively,

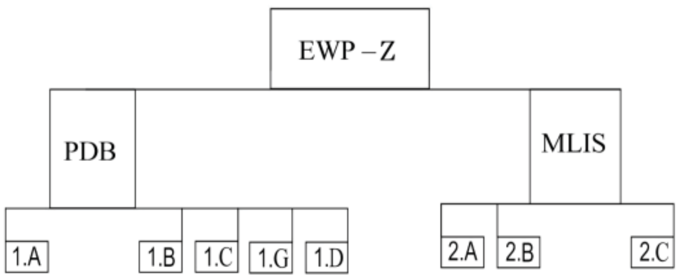

Fig. 5. **The scheme of electronic WP for ecologists and zoologists (EWP-Z):**
PDB-Z — own databases of zoologist: 1.A — electronic versions of publications selected by the scientist (printed versions of his own articles, prepared for publication, electronic versions of necessary articles of other authors); 1.B — database with information about substances and reagents; 1.C — DB with his own experimental, working data, monitoring data; 1.G — database with images; 1.D — DB with films of observations. MLIS is a mini-library Internet system for zoologists [1]

in the presence of additional functional unit (Fig. 6). The structural part marked at figure as 1.G is fundamentally different from that of those scientists who do not engage in neurophysiology (for example, zoologists) because it contains digitized records of electrical signals-responses of single neurons to corresponding stimuli.

Personal database of neurophysiologists. The first part of the EWP-NF contained "personal database" of the neurophysiologist — EWP-NF, which is subdivided into components, some of which were similar, and some of them were different from abovedescribed analogs:

1. The database of electronic versions of articles, abstracts (similar to the previous EWP).

2. Database of reagents, chemicals and biochemical compounds.

3. Database with experimental information. This part is fundamentally different from that of the previous EWP, since in the experiment the neurophysiologist writes the electrical signals — the responses of the neurons to stimulation. Being digitized, these signals were written to the local database of experimenter. Part 3 is subdivided into several parts. 1. DB with protocols of standard conditions for conducting experiments. 2. Data of daily experiments in digital form. 3. Processed and analyzed data in the form of charts or tables. These materials are subsequently transferred to the EWP-NF section, where the articles of the scientist were kept, which are ready for publication. During the last decade, the neurophysiologists database had increasingly accumulated results in the form of images: photos of neurons (with and without dyes), record of processes with optical registration, etc. Elaboration of such databases is aimed often at the further construction of medical expert systems — IS that automatically diagnose diseases, for example, of the brain. Such expert systems are the IS with databases and the WP for physician or neurophysiologist.

A separate unit is designed for the work with models, including animation models, record registration of the experiments. The material for such databases was, for example, simulation models, some of them we described in our previous publications [1, 7].

So, from two previous EWPs (EWP-H, EWP-Z), currently discussed EWP-NF differs by the presence of additional databases (and corresponding programs): 1 — DB records of electric currents and other biophysical characteristics; 2 — DB of brain images and its elements (similar to the insect database in EWP-Z); 3 — DB of animation models and record registration of the in digitized form.

The second part of EWP-NF is similar to the corresponding EWP-H and EWP-Z.

Thus, construction of electronic automated workplaces is prospective direction of technical works during the last decades. At the beginning of the article we suggested information about the development of the first AWPs, automated experiments for high professionals in neurosciences in Ukraine on 1980th.

Further we observed the works about the development of information system — AWP for other directions. This information system had proven itself well in practice of examining of athletes who specialize in cycling sports (highway cycling, speed skating, rowing), martial arts (freestyle wrestling), and alpinists of high-level qualification. This system also could provide significant support for the solution of complex of tasks connected with the organism improvement and with the development of general physical characteristics and special physical training of flight crews' members;

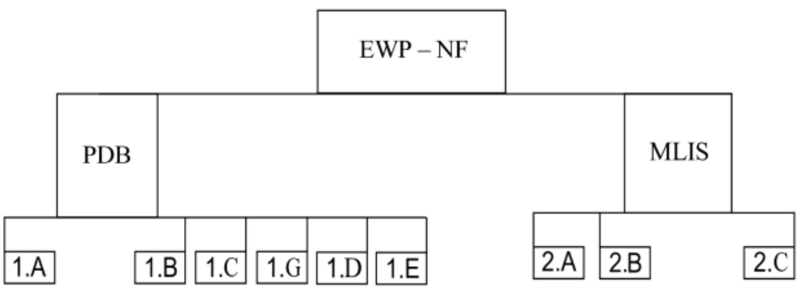

Fig. 6. **Scheme of electronic PM for neurotoxicologists and neurophysiologists(EWP-NF):** the main difference from the previous EWP — databases there contained the information necessary for the work of neurophysiologists. An additional unit 1.E contained the database of digitized records of electrical signals — the results of experiments [1]

training that is professionally oriented and aimed on the increasing of resistance to the influences of piloting overloads. This automated information system permitted the implementing of diagnostic algorithm for the estimation of functional state of flying crews' members. This AWP prototype suggested highly developed facilities mainly at local computer complex.

And finally, we observed the works for elaboration of electronic work places for professionals in three directions of biological sciences: EWP-H for professionals who studied hypoxia problems, EWP-Z for zoologists and EWP-NF for professionals in neurophysiology (biophysics, biochemists, and etc.) In comparison with previous AWP prototype these three workplaces were oriented both on local computer facilities development as well as on wide use of the Internet advantages. There some conclusions concerning these WP.

1. EWP-H, EWP-Z, and EWP-NF were proposed and their structures were observed. These WP were developed on the basis of knowledge of the process of daily work of specialists in this area of research, their requests and information needs, reagents, etc.

2. Constructed WP sufficiently fully met the requirements of experimenter both to make the necessary database, and to search necessary literature.

3. PDB as the main working part of EWP-H, EWP-Z, and EWP-NF quite well combined the functions of the "electronic protocol" of experimenter and bases of his own experimental data.

4. MLIS as an auxiliary part of EWP-H, EWP-Z, and EWP-NF satisfies the needs of a specialist both in theoretical and experimental data.

5. EWP-H, EWP-Z, and EWP-NF systems were easy to use.

Was it necessary to elaborate, for example, technical mini-librarian subsystem MLIS for EAWP, when the search for scientific information in the Internet is used in practice of many scientific groups today? The answer is "Yes" because MLIS was the first such prototype in Ukraine (1999–2002) that optimized scientific work in biology and could be used in biotechnology. It helped to organize the work of the widest range of researchers, both experienced and young scientists, to search for electronic information.

During the first steps of information systems use widely in scientific research there were some conflicts that the author would like to resolve constructing EWPs. These conflicts are following.

1) Some young scientists, enthusiastic about information search, were able to spend hours of work, "hanging" on the Internet;

2) Not knowing the principles of building and accessing individual databases, some users had to spend a lot of time searching, which sometimes causes their irritation reaction and refuse from the necessary search;

3) "Conflict between generation" resolution. In transitional period to Internet technologies, some older generation scientists on 1990th, without gaining skills in working with electronic information systems, sometimes avoided to work with them at all. This was a rather alarming phenomenon, since experienced scientists often had invaluable scientific work, ability to lead scientific groups, and ignoring the latest information achievements, they lose their position compared to colleagues experienced in the search for electronic information. MLIS facilitated the first steps of scientists from this group in working with the latest electronic resources. Doing her work for EWP-H, EWP-Z, and EWP-NF construction, the author tried to help users in such situations by constructing MLIS.

REFERENCES

1. *Klyuchko O. M.* Information and computer technologies in biology and medicine. *Kyiv: NAU-druk*. 2008, 252 p. (In Ukrainian).
2. *Aralova N. I., Klyuchko O. M., Shakhlina L. Ya.-H.* Parameters of athlete respiratory system dependence on organism hormonal status during hypoxic mixtures inhalation: research on mathematical models. *SciFed J. Sports Med., USA*. 2018, 1 (2). http://scifedpublishers.com/fulltext/parameters-of-athlete-respiratory-system-dependence-on-organism-hormonal-status-during-hypoxic-mixtures-inhalation-research-on-mathematical-models/22385#Figures
3. *Klyuchko O. M.* On the mathematical methods in biology and medicine. *Biotechnol. acta*. 2017, 10 (3), 31–40. https://doi.org/10.15407/biotech10.03.031
4. *Klyuchko O. M.* Application of artificial neural networks method in biotechnology. *Biotechnol. acta*. 2017, 10 (4), 5–13. https://doi.org/10.15407/biotech10.04.005
5. *Klyuchko O. M.* Cluster analysis in biotechnology. *Biotechnol. acta*. 2017,

10 (5), 5–18. https://doi.org/10.15407/biotech10.05.005
6. *Klyuchko O. M.* Technologies of brain images processing. *Biotechnol. acta.* 2017, 10 (6), 5–17. https://doi.org/10.15407/biotech10.05.005
7. *Klyuchko O. M., Onopchuk Yu. M.* Some trends in mathematical modeling for biotechnology. *Biotechnol. acta.* 2018, 11 (1), 39–57. https://doi.org/10.15407/biotech11.01.039
8. *Klyuchko O. M.* Electronic information systems in biotechnology. *Biotechnol. acta.* 2018, 11 (2), 5–22. https://doi.org/10.15407/biotech11.05.005
9. *Klyuchko O. M.* Information computer technologies for using in biotechnology: electronic medical information systems. *Biotechnol. acta.* 2018, 11 (3), 5–26.
10. *Schnase J.L., Cushing J., Frame M.* Information technology challenges of biodiversity and ecosystems informatics. *Inform. Syst.* 2003, 28 (4), 339–345.
11. *Piatigorsky B. Ya., Zaytman G. A., Cherkassky V. L., Chinarov V. A.* Automated electrophysiological experiment. *Kyiv: Naukova dumka.* 1985, 214 p. (In Russian).
12. *Patent* 1370136 USSR, C12N 5/00. The method for dissociation of hippocampal cells. *Klyuchko E. M., Tzyndrenko A. Ya.* Priority: 31. 01. 1986; Issued: 30. 01. 1988, Bull. No 4, 3 p.
13. *Hardy P. B., Sparks T. H., Isaak N. J.* Specialism for larval and adult consumer resources among Brittish butterflies: implications for conservation. *Biol. Conserv.*, 2007, 138 (3–4), 440–452.
14. *Dennis R. L. H., Shreeve T. G., Sparks T. H.* A comparison of geographical and neighbourhood models for improving atlas databases. The case of the French butterfly atlas. *Biol. Conserv*, 2002, 108 (2), 143–159.
15. *Klyuchko O. M., Paskivsky A. O., Sheremet D. Y.* Computer modeling of some nanoelements for radio and television systems. *Electronics and control systems.* 2012, 3 (33), 102–107. (In Ukrainian).
16. *Klyuchko O. M., Hayrutdinov R. R.* Modeling of electrical signals propagation in neurons and its nanostructures. *Electronics and control systems.* 2011, 2 (28), 120–124. (In Ukrainian).
17. *Trinus K. F., Klyuchko E. M.* Mediators influence on motoneurons retrogradly marked by primulin. *Physiol. J.* 1984. 30 (6), 730–733 (In Russian).
18. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Algorithmic and program support for optimization of interval hypoxic training modes selection of pilots. *Electronics and control systems.* 2017, 2 (52), 85–93.
19. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Mathematic and program models for investigation of reliability of operator professional activity in “Human-Machine” systems. *Electronics and control systems.* 2017, 1 (51), 105–113.
20. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Mathematical model for research of organism restoring for operators of continuously interacted systems. *Electronics and control systems.* 2016, 3 (49), 100–105.
21. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Investigation of reliability of operators work at fluctuating temperature conditions. *Electronics and control systems.* 2016, 2 (48), 132–139.
22. *Plakhotnij S. A., Klyuchko O. M., Krotinova M. V.* Information support for automatic industrial environment monitoring systems. *Electronics and control systems.* 2016, 1 (47), 19–34.
23. *Onopchuk Yu. M., Aralova N. I., Klyuchko O. M., Beloshitsky P. V.* Mathematic models and integral estimation of organism systems reliability in extreme conditions. *Electronics and control systems.* 2015, 4 (46), 109–115.
24. *Onopchuk Yu. M., Aralova N. I., Klyuchko O. M., Beloshitsky P. V.* Integral estimations of human reliability and working capacity in sports wrestling. *Journal of the Engineering Academy.* 2015, V. 3, P. 145–148. (In Russian).
25. *Klyuchko O. M., Shutko V. N., Navrotskyi D. O., Mikolushko A. M.* The set of program models for ecological monitoring technical system based on principles of biophysics. *Electronics and control systems.* 2014, 4 (42), 135–142.
26. *Klyuchko O. M., Sheremet D. Yu.* Computer simulation of biological nanogenerator functions. *Electronics and control systems.* 2014, 2 (40), 103–111.
27. *Klyuchko O. M., Shutko V. N.* Computer modeling of auto-oscillating phenomena in neuron complexes. *Electronics and control systems.* 2014, 1 (39), 127–132.
28. *Klyuchko O. M., Sheremet D. Yu.* Computer modeling of biologic voltage-activated nanostructures. *Electronics and control systems.* 2014, 1 (39), 133–139.
29. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu. M.* Radiation damage of organism and its correction in conditions of adaptation to highmountain meteorological factors. *Bul. NAU.* 2010, N 1, P. 224–231. (In Ukrainian).
30. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu., Makarenko M. V.* Estimation of psycho-physiological functions of a person and operator work in extreme conditions. *Bul. NAU.* 2009, N 3, P. 96–104. (In Ukrainian).
31. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu., Kolchinska A. Z.* Results of research of higher nervous activity problems by Ukrainian scientists in Prielbrussie. *Bul. NAU.* 2009, N 2, P. 105–112. (In Ukrainian).
32. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of structural and functional interdependencies by

Ukrainian scientists in Prielbrussie. *Bul. NAU*. 2009, N 1, P. 61–67. (In Ukrainian).
33. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of highlands factors influence on health and longevity by Ukrainian scientists in Prielbrussie. *Bul. NAU*. 2008, N 4, P. 108–117. (In Ukrainian).
34. *Onopchuk Yu. M., Klyuchko O. M., Beloshitsky P. V.* Development of mathematical models basing on researches of Ukrainian scientists at Elbrus. *Bul. NAU*. 2008, N 3, P. 146–155. (In Ukrainian).
35. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of adaptation problems by Ukrainian scientists in Prielbrussie. *Bul. NAU*. 2008, N 1, P. 102–108. (In Ukrainian).
36. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of hypoxia problems by Ukrainian scientists in Elbrus region. *Bul. NAU*. 2007, N 3–4, P. 44–50. (In Ukrainian).
37. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of medical and biological research of Ukrainian scientists at Elbrus. *Bul. NAU*. 2007, N 2, P. 10–16. (In Ukrainian).
38. *Belan P. V., Gerasimenko O. V., Tepikin A. V., Petersen O. H.* Localization of Ca^{++} extrusion sites in pancreatic acinar cells. *J. Biol. Chem*. 1996, V. 271, P. 7615–7619.
39. *Belan P., Gardner J., Gerasimenko O.* Extracellular Ca^{++} spikes due to secretory events in salivary gland cells. *J. Biol. Chem*. 1998, V. 273, P. 4106–4111.
40. *Jabs R., Pivneva T., Huttmann K.* Synaptic transmission onto hyppocampal glial cells with hGFAP promoter activity. *J. Cell Sci*. 2005, V. 118, P. 3791–3803.
41. *Linne C.* Fauna Suecica. *Stocholmiac*. 1761, 578 p.
42. *Klyuchko Z. F.* Noctuidae of the Western regions of Ukraine. *Kyiv: KyivUniv. Publ*. 1963, 176 p. (In Russian).
43. *Baert P., Meesen G., De Schynkel S., Poffijn A., Oostveldt P. V.* Simultaneous in situ profiling of DNA lesion endpoints based on image cytometry and a single cell database approach. *Micron*. 2005, 36 (4), 321–330. https://doi.org/10.1016/j.micron.2005.01.005
44. *Berks G., Ghassemi A., von Keyserlingk D. G.* Spatial registration of digital brain atlases based on fuzzy set theory. *Comp. Med. Imag. Graph*. 2001, 25 (1), 1–10. https://doi.org/10.1016/S0895-6111(00)00038-0
45. *Nowinski W. L., Belov D.* The Cerefy Neuroradiology Atlas: a Talairach–Tournoux atlas-based tool for analysis of neuroimages available over the internet. *NeuroImage*. 2003, 20 (1), 50–57. https://doi.org/10.1016/S1053-8119(03)00252-0
46. *Chaplot S., Patnaik L. M., Jagannathan N. R.* Classification of magnetic resonance brain images using wavelets as input to support vector machine and neural network. *Biomed. Signal Proc. Contr*. 2006, 1 (1), 86–92. https://doi.org/10.1016/j.bspc.2006.05.002
47. *Kovalev V. A., Petrou M., Suckling J.* Detection of structural differences between the brains of schizophrenic patients and controls. *Psych. Res.: Neuroimaging*. 2003, 124 (3), 177–189. https://doi.org/10.1016/S0925-4927(03)00070-2
48. *Araújo T.* Classification of breast cancer histology images using Convolutional Neural Networks. *PloS One*. 2017, 12 (6), e0177544.
49. *Vecht-Lifshitz S. E., Ison A. P.* Biotechnological applications of image analysis: present and future prospects. *J. Biotechnol*. 1992, 23 (1), 1–18.
50. *Toga A. W., Thompson P. M.* The role of image registration in brain mapping. *Image Vis. Comput*. 2001, 19 (1–2), 3–24.
51. *Carro S. A., Scharcanski J.* A framework for medical visual information exchange on the WEB. *Computers in Biology and Medicine*. 2006, V. 4, P. 327–338.
52. *Chakravarty M. M., Bertrand G., Hodge C. P., Sadikot A. F., Collins D. L.* The creation of a brain atlas for image guided neurosurgery using serial histological data. *NeuroImage*. 2006, 30 (2), 359–376. https://doi.org/10.1016/j.neuroimage.2005.09.041
53. *Dikshit A., Wu D., Wu C., Zhao W.* An online interactive simulation system for medical imaging education. *Comp. Med. Imag. Graph*. 2005, 29 (6), 395–404. https://doi.org/10.1016/j.compmedimag.2005.02.001
54. *Singh R., Schwarz N., Taesombut N., Lee D., Jeong B., Renambot L., Lin A. W., West R., Otsuka H., Naito S., Peltier S. T., Martone M. E., Nozaki K., Leigh J., Ellisman M. H.* Real-time multi-scale brain data acquisition, assembly, and analysis using an end-to-end. *OptIPuter Future Generation Computer Systems*. 2006, V. 22, P. 1032–1039.
55. *Stefanescu R., Pennec X., Ayache N.* Grid powered nonlinear image registration with locally adaptive regularization. *Med. Image Anal*. 2004, 8 (3), 325–342.
56. *Ma Y., Hof P. R., Grant S. C., Blackband S. J., Bennett R., Slatest L., McGuigan M. D., Benveniste H.* A three-dimensional digital atlas database of the adult C57BL/6J mouse brain by magnetic resonance microscopy. *Neuroscience*. 2005, 135 (4), 1203–1215. https://doi.org/10.1016/j.neuroscience.2005.07.014
57. *Yu-Len Huang*. Computer-aided Diagnosis Using Neural Networks and Support Vector Machines for Breast Ultrasonography. *J. Med. Ultrasound*. 2009, 17 (1), 17–24.
58. *Prachi Damodhar Shahare, Ram Nivas Giri*. Comparative Analysis of Artificial Neural Network and Support Vector Machine Classification for Breast Cancer Detection.

International Research Journal of Engineering and Technology (IRJET). 2015, 2 (9).
59. *Natrajan R., Sailem H., Mardakheh F. K., Garcia M. F., Tape C. G., Dowsett M., Bakal C., Yuan Y.* Microenvironmental heterogeneity parallels breast cancer progression: a histology–genomic integration analysis. *PLoS Med.* 2016. 13 (2), e1001961. https://doi.org/10.1371/journal.pmed.1001961
60. *Klyuchko O. M.* Brain images in information systems for neurosurgery and neurophysiology. *Electronics and control systems.* 2009, 3 (21), 152–156. (In Ukrainian).
61. *Klyuchko O. M.* Using of images' databases for diagnostics of pathological changes in organism tissues. *Electronics and control systems.* 2009, 2 (20), 62–68. (In Ukrainian).
62. *Klyuchko O. M.* Elements of different level organization of the brain as material for electronic databases with images. *Electronics and control systems.* 2009, 1 (19), 69–75. (In Ukrainian).
63. *Steimann F.* On the representation of roles in object-oriented and conceptual modelling. *Data& Knowedge Engin.* 2000, 35 (1), 83–106.
64. *Klyuchko O. M., Managadze Yu. L., Pashkivsky A. O.* Program models of 2D neuronal matrix for ecological monitoring and images' coding. *Bulletin of the Engineering Academy.* 2013, No 3–4, P. 77–82. (In Ukrainian).
65. *Klyuchko O. M., Piatchanina T. V., Mazur M. G.* Combined use of relation databases of images for diagnostics, therapy and prognosis of oncology diseases. "*Integrated robototechnic complexes*". *X IIRTC-2017 Conference Proceedings.* P. 275–276. (In Ukrainian).
66. *Shutko V. M., Shutko O. M., Kolganova O. O.* Methods and means of compression of information. *Kyiv: Nauk. dumka.* 2012, 168 p. (In Ukrainian).
67. *Jecheva V., Nikolova E.* Some clusteringbased methodology applications to anomaly intrusion detection systems. *Int. J. Secur. Appl.* 2016, 10 (1), 215–228. http://dx.doi.org/10.14257/ijsia.2016.10.1.20
68. *Iakovidis D. K., Maroulis D. E., Karkanis S. A.* Texture multichannel measurements for cancer precursors' identification using support vector machines. *Measurement.* 2004, V. 36, P. 297–313. 2004.09.010 https://doi.org/10.1016/j.measurement
69. *Nguyen H. Q., Carrieri-Kohlman V., Rankin S. H., Slaughter R., Stulbarg M. S.* Internet-based patient education and support interventions: a review of evaluation studies and directions for future research. *Comp. Biol. Med.* 2004, 34 (2), 95–112. https://doi.org/10.1016/S0010-4825(03)00046-5
70. *Jézéquel P., Loussouarn L., Guérin-Charbonnel C., Campion L., Vanier A., Gouraud W., Lasla H., Guette C., Valo I., Verrièle V. Campone M.* Gene-expression molecular subtyping of triple-negative breast cancer tumours: importance of immune response. *Breast Cancer Res.* 2015, 17 (1), 43. https://doi.org/10.1186/s13058-015-0550-y
71. *Bozhenko V. K.* Multivariable analysis of laboratory blood parameters for obtaining diagnostic information in experimental and clinical oncology. The dissertation author's abstract on scientific degree editions. *Dc. Med. Study. Moscow.* 2004. (In Russian).
72. *Ko J. H., Ko E. A., Gu W., Lim I., Bang H., Zhou T.* Expression profiling of ion channel genes predicts clinical outcome in breast cancer. *Mol. Cancer.* 2013, 12 (1), 106. https://doi.org/10.1186/1476-4598-12-106
73. *Kawai M., Nakashima A., Kamada S., Kikkawa U.* Midostaurin preferentially attenuates proliferation of triple-negative breast cancer cell lines through inhibition of Aurora kinase family. *J. Biomed. Sci.* 2015, 22 (1), 48. https://doi.org/10.1186/s12929-015-0150-2
74. *Uhr K., Wendy J. C., Prager-van der Smissen, Anouk A. J. Heine, Bahar Ozturk, Marcel Smid, Hinrich W. H. Göhlmann, Agnes Jager, John A. Foekens, John W. M. Martens.* Understanding drugs in breast cancer through drug sensitivity screening. *SpringerPlus.* 2015, 4 (1), 611. https://doi.org/10.1186/s40064-015-1406-8
75. *Onopchuk Yu. M., Biloshitsky P. V., Klyuchko O. M.* Development of mathematical models based on the results of researches of Ukrainian scientists at Elbrus. *Bul. NAU.* 2008, N 3, P. 146–155. (In Ukrainian).
76. *Ankur Poudel, Dhruba Bahadur Thapa, Manoj Sapkota.* Cluster Analysis of Wheat (Triticum aestivum L.) Genotypes Based Upon Response to Terminal Heat Stress. *Int. J. Appl. Sci. Biotechnol.* 2017, 5 (2), 188–193. http://dx.doi.org/10.3126/ijasbt.v5i2.17614
77. *Zaslavsky L., Ciufo S., Fedorov B., Tatusova T.* Clustering analysis of proteins from microbial genomes at multiple levels of resolution. *BMC Bioinform.* 2016, 17 (8), 276. Published online 2016 Aug 31. https://doi.org/10.1186/s12859-016-1112-8
78. *Zhou J., Richardson A. J., Rudd K. E.* EcoGene-RefSeq: EcoGene tools applied to the RefSeq prokaryotic genomes. *Bioinformatics.* 2013, 29 (15), 1917–1918. Published: 04 June 2013. https://doi.org/10.1093/bioinformatics/btt302
79. *Zhang J., Wu G., Hu X., Li S., Hao S.* A Parallel Clustering Algorithm with MPI — MKmeans. *J. Comput.* 2013, 8 (1), 10–17. https://doi.org/10.1109/PAAP.2011.17
80. *Tatusova T., Zaslavsky L., Fedorov B., Haddad D., Vatsan A., Ako-adjei D., Blinkova O., Ghazal H.* Protein Clusters. *The NCBI Handbook [Internet]. 2nd edition.* Available at https://www.ncbi.nlm.nih.gov/books/NBK242632

81. *Anderson J. G.* Evaluation in health informatics: computer simulation. *Computers in Biology and Medicine*. 2002, 32 (3), 151–164. https://doi.org/10.1016/S0010-4825(02)00012-4
82. *Aruna P., Puviarasan N., Palaniappan B.* An investigation of neuro-fuzzy systems in psychosomatic disorders. *Exp. Syst. Appl*. 2005, 28 (4), 673–679. https://doi.org/10.1016/j.eswa.2004.12.024
83. *Bange M. P., Deutscher S. A., Larsen D., Linsley D., Whiteside S.* A handheld decision support system to facilitate improved insect pest management in Australian cotton systems. *Comp. Electron. Agricult*. 2004, 43 (2), 131–147. https://doi.org/10.1016/j.compag.2003.12.003
84. *Beaulieu A.* From brainbank to database: the informational turn in the study of the brain. *Stud. Hist. Phil. Biol. Biomed. Sci.* 2004, V. 35, P. 367–390. https://doi.org/10.1016/j.shpsc.2004.03.011
85. *Horn W.* AI in medicine on its way from knowledge-intensive to data-intensive systems. *Artificial Intelligence in Medicine. Elsevier*. 2001, 23 (1), 512. https://doi.org/10.1016/S0933-3657(01)00072-0
86. *Brake I.* Unifying revisionary taxonomy: insect exemplar groups. *Abstr. XV SEL Congr. Berlin (Germany)*. 2007.
87. *Braxton S. M., Onstad D. W., Dockter D. E., Giordano R., Larsson R., Humber R.A.* Description and analysis of two internet-based databases of insect pathogens: EDWIP and VIDIL. *J. Invertebr. Pathol.* 2003, 83 (3), 185–195. https://doi.org/10.1016/S0022-2011(03)00089-2
88. *Breaux A., Cochrane S., Evens J., Martindaled M., Pavlike B., Suera L., Benner D.* Wetland ecological and compliance assessments in the San Francisco Bay Region, California, USA. *J. Environm. Manag*. 2005, 74 (3), 217–237.
89. *Budura A., Cudré-Mauroux P., Aberer K.* From bioinformatic web portals to semantically integrated Data Grid networks. *Fut. Gener. Comput. Syst*. 2007, 23 (3), 281–522. https://doi.org/10.1016/j.jenvman.2004.08.017
90. *Burns G., Stephan K. E., Ludäscher B., Gupta A., Kötter R.* Towards a federated neuroscientific knowledge management system using brain atlases. *Neurocomputing*. 2001, V. 3840, P. 1633–1641. https://doi.org/10.1016/S0925-2312(01)00520-3
91. *Butenko S., Wilhelm W. E.* Clique-detection models in computational biochemistry and genomics. *Eur. J. Oper. Res.* 2006, 173 (1), 117. https://doi.org/10.1016/j.ejor.2005.05.026
92. *Carro S. A., Scharcanski J.* Framework for medical visual information exchange on the WEB. *Comp. Biol. Med.* 2006, 36 (4), 327–338. https://doi.org/10.1016/j.compbiomed.2004.10.004
93. *Chau M., Huang Z., Qin J., Zhou Y., Chen H.* Building a scientific knowledge web portal: The NanoPort experience. *Decision Support Systems*. 2006. https://doi.org/10.1016/j.dss.2006.01.004
94. *Chen M., Hofestädt R.* A medical bioinformatics approach for metabolic disorders: Biomedical data prediction, modeling, and systematic analysis. *J. Biomed. Inform*. 2006, 39 (2), 147–159. https://doi.org/10.1016/j.jbi.2005.05.005
95. *Chli M., De Wilde P.* Internet search: Subdivision-based interactive query expansion and the soft semantic web. *Appl. Soft Comput*. 2006. https://doi.org/10.1016/j.asoc.2005.11.003
96. *Despont-Gros C., Mueller H., Lovis C.* Evaluating user interactions with clinical information systems: A model based on human — computer interaction models. *J. Biomed. Inform*. 2005, 38 (3), 244–255. https://doi.org/10.1016/j.jbi.2004.12.004
97. *Marios D., Dikaiakos M. D.* Intermediary infrastructures for the World Wide Web. *Comp. Networks*. 2004, V. 45, P. 421–447. https://doi.org/10.1016/j.comnet.2004.02.008
98. *Dimitrov S. D., Mekenyan O. G., Sinks G. D., Schultz T. W.* Global modeling of narcotic chemicals: ciliate and fish toxicity. *J. Mol. Struc.: Theochem*. 2003, 622 (12), 63–70. https://doi.org/10.1016/S0166-1280(02)00618-8
99. *Dong Y., Zhuang Y., Chen K., Tai X.* A hierarchical clustering algorithm based on fuzzy graph connectedness. *Fuzzy Sets. Syst*. 2006, V. 157, P. 1760–1774. https://doi.org/10.1016/j.fss.2006.01.001
100. *Duan Y., Edwards J. S., Xu M. X.* Web-based expert systems: benefits and challenges. *Inf. Manag*. 2005, 42 (6), 799–811. https://doi.org/10.1016/j.im.2004.08.005
101. *Essen van D. C.* Windows on the brain: the emerging role of atlases and databases in neuroscience. *Curr. Opin. Neurobiol.* 2002, 12 (5), 574–579. https://doi.org/10.1016/S0959-4388(02)00361-6
102. *Fellbaum C., Hahn U., Smith B.* Towards new information resources for public health From Word Net to Medical Word Net. *J. Biomed. Inform*. 2006, 39 (3), 321–332. https://doi.org/10.1016/j.jbi.2005.09.004
103. *Ferraris M., Frixione P., Squarcia S.* Network oriented radiological and medical archive. *Comp. Physics Commun.* 2001, V. 140, P. 226–232. https://doi.org/10.1016/S0010-4655(01)00273-9
104. *Flower D. R., Attwood T. K.* Integrative bioinformatics for functional genome annotation: trawling for G protein-coupled receptors. Reviews 55 Semin. *Cell. Dev. Biol*. 2004, 15 (6), 693–701. https://doi.org/10.1016/j.semcdb.2004.09.008

105. *Fink E., Kokku P. K., Nikiforou S., Hall L. O., Goldgof D. B., Krischer J. P.* Selection of patients for clinical trials: an interactive webbased system. *Art. Intell. Med.* 2004, 31 (3), 241–254. https://doi.org/10.1016/j.artmed.2004.01.017
106. *Fitzpatrick M. J., Ben-Shahar Y., Smid H. M., Vet L. E., Robinson G. E., Sokolowski M. B.* Candidate genes for behavioural ecology. *Trend Ecol. Evol.* 2005, 20 (2), 96–104. https://doi.org/10.1016/j.tree.2004.11.017
107. *Fox J., Alabassi A., Patkar V., Rose T., Black E.* An ontological approach to modeling tasks and goals. *Comp. Biol. Med.* 2006, V. 36, P. 837–856. https://doi.org/10.1016/j.compbiomed.2005.04.011
108. *Fu Zetian, Xu Feng, Zhou Yun, Shuan X. Z.* Pig-vet: a web-based expert system for pig disease diagnosis. 2006. https://doi.org/10.1016/j.eswa.2005.01.011
109. *Gaulton A., Attwood T. K.* Bioinformatics approaches for the classification of G-protein-coupled receptors. *Curr. Opin. Pharmacol.* 2003, 3 (2), 114–120. https://doi.org/10.1016/S1471-4892(03)00005-5
110. *Palla K., Ghahramani Z., Knowles D. A.* A nonparametric variable clustering model. *Adv. Neural Inform. Proc. Syst.* 2012, P. 2987–2995.
111. *Curtis C., Shah S. P., Chin S. F., Turashvili G., Rueda O. M., Dunning M. J., Speed D., Lynch A. G., Samarajiwa S., Yuan Y., Gräf S., Ha G., Haffari G., Bashashati A., Russell R., McKinney S., Langerød A., Green A., Provenzano E., Wishart G., Pinder S., Watson P., Markowetz F., Murphy L., Ellis I., Purushotham A., Dale A. L., Brenton J. D., Tavaré S., Caldas C., Aparicio S.* The genomic and transcriptomic architecture of 2,000 breast tumours reveals novel subgroups. *Nature.* 2012, 486 (7403), 346–352.
112. *Proceedings* Of the second EuroLOOP Workshop, Amsterdam, 27–30 March 1995.
113. *Graham C. H., Ferrier S., Huettman F., Moritz C., Peterson A. T.* New developments in museum-based informatics and applications in biodiversity analysis. *Trend. Ecol. Evol.* 2004, 19 (9), 497–503. https://doi.org/10.1016/j.tree.2004.07.006
114. *Anokhin B., Hemmrich G.* Zoology www guide. *Zoology.* 2005, 108 (4), 673–679.
115. *Hirano S., Sun X., Tsumoto S.* Comparison of clustering methods for clinical databases. *Inform. Sci.* 2004, 159 (34), 155–165. https://doi.org/10.1016/j.ins.2003.03.011
116. *Hong Yu., Hatzivassiloglou V., Rzhetsky A., Wilbur W. J.* Automatically identifying gene/protein terms in MEDLINE abstracts. *J. Biomed. Inform.* 2002, 35 (56), 322–330. https://doi.org/10.1016/S1532-0464(03)00032-7
117. *Bedathur S. J., Haritsa J. R., Sen U. S.* The building of BODHI, a bio-diversity database system. *Inform. Syst.* 2003, 28 (4), 347–367. https://doi.org/10.1016/S0306-4379(02)00073-X
118. *Hsi-Chieh Lee, Szu-Wei Huang, Li E. Y.* Mining protein–protein interaction information on the internet. *Exp. Syst. Appl. Elsevier.* 2006, 30 (1), 142–148. https://doi.org/10.1016/j.eswa.2005.09.083
119. *Young R.* Genetic toxicology: web–resources. *Toxicology.* 2002, 173 (1–2), 103–121.
120. *Johnson S. B., Friedman R.* Bridging the gap between biological and clinical informatics in a graduate training program. *J. Biomed. Inform.* 2007, 40 (1), 59–66. Epub. 2006 Mar 15. https://doi.org/10.1016/j.jbi.2006.02.011
121. *Kaiser M., Hilgetag C. C.* Modelling the development of cortical systems networks. *Neurocomputing.* 2004, V. 5860, P. 297–302. https://doi.org/10.1016/j.neucom.2004.01.059
122. *Kane M. D., Brewer J. L.* An information technology emphasis in biomedical informatics education. *J. Biomed. Inform.* 2007, 40 (1), 67–72. https://doi.org/10.1016/j.jbi.2006.02.006
123. *Kannathal N., Acharya U. R., Lim C. M., Sadasivan P. K.* Characterization of EEG. A comparative study. *Comp. Meth. Progr. Biomed.* 2005, 80 (1), 17–23. https://doi.org/10.1016/j.cmpb.2005.06.005
124. *Koh W., McCormick B. H.* Brain microstructure database system: an exoskeleton to 3D reconstruction and modelling. *Neurocomputing.* 2002, V. 4446, 1099–1105. https://doi.org/10.1016/S0925-2312(02)00426-5
125. *Koh W., McCormick B. H.* Registration of a 3D mouse brain atlas with brain microstructure data. *Neurocomputing.* 2003, V. 5254, P. 307–312. https://doi.org/10.1016/S0925-2312(02)00793-2
126. *Kulish V., Sourin A., Sourina O.* Human electro encephalograms seen as fractal time series: Mathematical analysis and visualization. *Comp. Biol. Med.* 2006, 36 (3), 291–302. https://doi.org/10.1016/j.compbiomed.2004.12.003
127. *Lubitz von D., Wickramasinghe N.* Networkcentric healthcare and bioinformatics: Unified operations within three domains of knowledge. *Exp. Syst. Appl.* 2006, 30 (1), 11–23. https://doi.org/10.1016/j.eswa.2005.09.069
128. *Martin-Sanchez F., Iakovidis I., Norager S., Maojo V., de Groen P., Van der Lei J., Jones T., Abraham-Fuchs K., Apweiler R., Babic A., Baud R., Breton V., Cinquin P., Doupi P., Dugas M., Eils R., Engelbrecht R., Ghazal P., Jehenson P., Kulikowski C., Lampe K., De Moor G., Orphanoudakis S., Rossing N., Sarachan B., Sousa A., Spekowius G., Thireos G.,*

Zahlmann G., Zvárová J., Hermosilla I., Vicente F. J. Synergy between medical informatics and bioinformatics: facilitating genomic medicine for future health care. *J. Biomed. Inform.* 2004, 37 (1), 30–42. https://doi.org/10.1016/j.jbi.2003.09.003
129. *Masseroli M., Visconti A., Bano S. G. Pinciroli F.* He@lthCo-op: a web-based system to support distributed healthcare co-operative work. *Comp. Biol. Med.* 2006, 36 (2), 109–127. https://doi.org/10.1016/j.compbiomed.2004.09.005
130. *Moon S., Byun Y., Han K.* FSDB: A frameshift signal database. *Comp. Biol. Chem.* 2007, 31 (4), 298–302. https://doi.org/10.1016/j.compbiolchem.2007.05.004
131. *Orgun B., Vu J.* HL7 ontology and mobile agents for interoperability in heterogeneous medical information systems. *Comp. Biol. Med.* 2006, 36 (78), 817–836. https://doi.org/10.1016/j.compbiomed.2005.04.010
132. *Pérez-Rey D., Maojo V., García-Remesal M., Alonso-Calvo R., Billhardt H., Martin-Sánchez F., Sousa A.* Ontofusion: Ontology-based integration of genomic and clinical databases. *Comp. Biol. Med.* 2006, 36 (78), 712–730. https://doi.org/10.1016/j.compbiomed.2005.02.004
133. *Krishtal O. A., Kiskin N. I., Tsyndrenko A. Ya., Klyuchko E. M.* Pharmacological properties of amino acid receptors in isolated hippocampal neurons. *In: Receptors and ion channels. Ed. By Ovchinnikov Y. A., Hucho F. Berlin-New York: Walter de Gruyter.* 1987, P. 127–137.
134. *Klyuchko E. M., Klyuchko Z. F., Beloshitsky P. V.* Some adaptation characteristics of insects in mountains of Prielbrussie. *Nalchik (Russia), "Hypoxia: automatic analysis of hypoxic states of healthy people and sick ones".* 2005, V. 1, P. 137–140. (In Russian).
135. *Klyuchko Z. F., Klyuchko E. M.* Analysis of taxonomic structure of moth fauna (*Lepidoptera*: *Noctuidae* s. l.) of Ukraine according to monitoring data. *Eversmannia.* 2012, 3 (33), 41–45. (In Russian).
136. *Klyuchko Z. F., Klyuchko E. M.* Moth (*Lepidoptera*: *Noctuidae* s. l.) of Chercasska region of Ukraine according to results of many-year monitoring. *Eversmannia.* 2014, V. 37, P. 32–49. (In Russian).
137. *Gonchar O., Klyuchko O., Seredenko M., Oliynyk B.* Correction of metabolic disorders at hypoxia by new pharmacological preparations. *Mater. 3 FEPS Congress. Nice (France).* 2003, P. 228.
138. *Seredenko M., Gonchar O., Klyuchko O., Oliynyk S.* Peculiarities of prooxidant — antioxidant balance of organism under hypoxia of different genesis and its corrections by new pharmacological preparations. *Acta Physiologica Hungarica. Budapest (Hungary).* 2002, 89 (1–3), 292.
139. *Klyuchko O., Klyuchko Z., Lizunova A.* Electronic Noctuidae database: some problems and solutions. *Proceed. 16th European Congress of Lepidopterology. Cluj (Romania).* 2009, P. 31–32.
140. *Klyuchko O., Klyuchko Z., Lizunova A.* Noctuidae fauna of Ukrainian Karpathy: results of monitoring (1956–2008). *Proceed. 16th European Congress of Lepidopterology. Cluj (Romania).* 2009, P. 31.
141. *Klyuchko O. M., Beloshitsky P. V.* Investigation of insect adaptation characteristics in Prielbrussie in 2004–2005. *Mater. VIII World Congress of International Society for Adaptive Medicine (ISAM). Moskva (Russia).* 2006, P. 165–166.
142. *Beloshitsky P. V., Klyuchko O. M.* Contribution of Sirotinin's school into adaptation medicine. *Mater. VIII World Congress of International Society for Adaptive Medicine (ISAM). Moskva (Russia).* 2006, P. 158.
143. *Klyuchko O. M., Klyuchko Z. F.* Ukrainian Noctuidae Database. *Mater. of XIV SEL Congress. Roma (Italy).* 2005, P. 49.
144. *Klyuchko Z. F., Klyuchko O. M.* Noctuidae (Lepidoptera) of Donbass, Ukraine. *Mater. of XIV SEL Congress. Roma (Italy).* 2005, P. 41–42.
145. *Beloshitsky P., Klyuchko O., Onopchuck Yu., Onopchuck G.* Mathematic model for hypoxic states development for healthy people and ones with ischemic heart disease. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China).* 2004, V. 5, P. 251.
146. *Beloshitsky P., Klyuchko O., Kostyuk O., Beloshitsky S.* Peculiarities of high mountain factors influence on organism. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China).* 2004, V. 5, P. 250.
147. *Klyuchko O. M., Kiskin N. I., Krishtal O. A., Tsyndrenko A. Ya.* Araneidae toxins as antagonists of excitatory amino acid responses in isolated hippocampal neurons. *X School on biophysics of membrane transport. Szczyrk (Poland).* 1990, V. 2, P. 271.
148. *Akaike N., Kawai N., Kiskin N. I., Krishtal O. A., Tsyndrenko A. Ya., Klyuchko O. M.* Spider toxin blocks excitatory amino acid responses in isolated hippocampal pyramidal neurons. *Neurosci. Lett.* 1987, V. 79, P. 326–330.
149. *Gonchar O., Klyuchko O., Beloshitsky P.* Ways of myocardial metabolic disorders correction at hypoxia by new pharmacological preparations. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China).* 2004, V. 5, P. 249.
150. *Gonchar O., Klyuchko E., cMankovskaya I.* Role of complex nucleosides in the reversal of oxidative stress and metabolic disorders induced by acute nitrite poisoning. *Ind. J. Pharmacol.* 2006, 38 (6), 414–418.

151. *Gonchar O., Klyuchko E., Seredenko M., Oliynik S.* Corrections of prooxidant — antioxidant homeostasis of organism under hypoxia of different genesis by yackton, new pharmacological preparation. *Acta Physiol. Pharmacol. Bulg.* 2003, V. 27, P. 53–58.
152. *Klyuchko O. M., Tzal-Tzalko V. I.* Elaboration of new monitoring system for Ukrainian Polissia conditions with data defence. *Bulletin of Engineering Academy.* 2014, V. 2, P. 239–246. (In Ukrainian).
153. *Klyuchko O. M., Piatchanina T. V., Mazur M. G., Basarak O. V.* Ontological methods in the development of biomedical information systems. "*Integrated intellectual robototechnical complexes*" — "*IIRTC-2018*": *Materials of XI Intl. Scient. Tech. Conference.* 2018, P. 270–272. (In Ukrainian).
154. *Klyuchko O. M., Piatchanina T. V., Mazur M. G., Basarak O. V.* Elaboration of network-based biomedical systems with databases. "*Integrated intellectual robototechnical complexes*" — "*IIRTC-2018*": *Materials of XI Intl. Scient. Tech. Conference.* 2018, P. 273–274. (In Ukrainian).
155. *Aralova N. I., Klyuchko O. M.* Mathematic modeling of functional self-organization of pilots' respiratory systems. "*Integrated intellectual robototechnical complexes*" — "*IIRTC-2018*": *Materials of XI Intl. Scient. Tech. Conference.* 2018, P. 268–269. (In Ukrainian).
156. *Klyuchko Z. F., Klyuchko O. M.* Monitoring of the diversity of Noctuidae (Lepidoptera) fauna in Ukrainian Polissia. "*Nature of Polissia: investigation and protection*": *Materials of Intl. Scient. Conference.* 2014, P. 498–502. (In Ukrainian).
157. *Klyuchko Z. F., Klyuchko O. M., Lizunova A. G.* Monitoring of Noctuidae fauna of Ukraine using electronic information systems. "*Nature of Polissia: investigation and protection*": *Materials of Intl. Scient. Conference.* 2014, P. 261–265. (In Ukrainian).
158. *Biloshitsky P. V., Klyuchko O. M.* Studying of sport medicine problems at Elbrus Medical and Biological Station. World Congress in Mountain Medicine. Chronic Hypoxia Symposium. LaPaz, Bolivia. Feb 23–Mar 2, 2019. P. 18.
159. *Aralova N. I., Biloshitsky P. V., Klyuchko O. M.* Mathematical models of system mechanisms of organism adaptation to hypoxia. World Congress in Mountain Medicine. Chronic Hypoxia Symposium. LaPaz, Bolivia. Feb 23–Mar 2, 2019. P. 17.
160. *Klyuchko O. M., Klyuchko Z. F.* Electronic databases for Arthropods: methods and applications. *Biotechnol. acta.* 2018, 11 (4), 28–49. https://doi.org/10.15407/biotech11.04.028
161. *Klyuchko O. M., Klyuchko Z. F.* Electronic information systems for monitoring of populations and migrations of insects. *Biotechnol. acta.* 2018, 11 (5), 5–25. https://doi.org/10.15407/biotech11.05.005
162. *Klyuchko O. M.* Expert systems for biology and medicine. *Biotechnol. acta.* 2018, 11 (6), 5–28. https://doi.org/10.15407/biotech11.06.005
163. *Klyuchko O. M.* Biotechnical information systems for monitoring of chemicals in environment: biophysical approach. *Biotechnol. acta.* 2019, 12 (1), 5–28. https://doi.org/10.15407/biotech
164. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of bio-sensor test system application. *Patent UA 129923 U, G01N33/00, G01N33/50, C12Q 1/02.* Priority: 22.03.2018, u201802896, Issued: 26.11.2018, Bull. 22, 7 p. (In Ukrainian).
165. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of application of biotechnical monitoring system with biosensor (biosensor test system). *Patent UA 132245 U; G01N33/50.* Priority: 22. 03. 2018 u201802893, Issued: 25. 02. 2019, Bull. 4, 7 p. (In Ukrainian).
166. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of application of biotechnical monitoring system with biosensor and subsystem for optical registration. *Patent UA 129922 U, G01N33/50.* Priority: 22. 03. 2018, u201802894; Issued: 26. 11. 2018, Bull. 22, 10 p. (In Ukrainian).
167. *Klyuchko O. M.* Method of application of biotechnical monitoring system for bioindicators' accounting with biosensor and sub-system for optical registration. *Patent UA 129987 U, G01N33/00, C12Q 1/02, C12N 15/00.* Priority: 27. 04. 2018, u201804662: Issued: 26.11.2018, Bull. 22, 11 p. (In Ukrainian).
168. *Klyuchko O. M.* Method for cells' dissociation. *Patent UA 130672 U, G01N 33/00, C12Q 1/02, C12N 15/00.* Priority: 27. 04. 18, u201804668, Issued: 26. 12. 2018, Bull. 24, 7 p. (In Ukrainian).
169. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D.* Method of application of biotechnical monitoring system with expert subsystem and biosensor. *Patent UA 131863 U; G01N33/00, C12Q 1/02, C12N 15/00.* Priority: 27. 04. 18, u201804663, Issued: 11. 02. 2019, Bull. 3, 7 p. (In Ukrainian).
170. *Klyuchko O. M.* Method of qualitative analysis of chemical substances. *Patent UA 131016 U, G01N33/50, G01N21/78, C12Q 1/60.* Priority: 11. 05. 2018, u201805174, Issued: 10. 01. 2019, Bull. 1. (In Ukrainian).
171. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. A.* Method of quantitative analysis of chemical substances. *Patent UA 131524 U; G01N33/50, G01N21/78, C12Q 1/60.*

Priority: 11. 05. 2018, u201805175, Issued: 25. 01. 2019, Bull. 2, 10 p. (In Ukrainian).
172. *Klyuchko O. M., Biletsky A. Ya.* Method of qualitative analysis of chemical substances for the influence on electrical currents in bioobjects. *Patent UA; G01N 33/50, G01N 21/78, C12Q 1/60*. Priority: May 2018, u201806345. (In Ukrainian).
173. *Klyuchko O. M., Biletsky A. Ya.* Method of qualitative analysis of hydrocarbons with a high and toxic effect on bioobjects. *Patent UA 133676 U; G01N 33/50, G01N 21/78*. Priority: 06.06.2018, u201806342, Issued: 25.04.2019, Bull. 8, 10 p. (In Ukrainian).
174. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of monitoring of chemical substances' infuences on organisms in few time intervals. *Patent UA; G01N33/00, C12Q 1/02*. Priority: 14. 12. 2018, u201812443. (In Ukrainian).
175. *Klyuchko O. M., Biletsky A. Ya., Shutko V. N.* Method for constructing and testing of physical molecular memory in anisotropic media with molecules — derivatives of phenol. *Patent UA; H01B1/121, G01N33/00, C12Q 1/02*. Priority: 14. 12. 2018, u201812430. (In Ukrainian).
176. *Klyuchko O. M., Biletsky A. Ya., Lizunov G. V., Shutko V. N.* Method of electrical signals generating by bio-elements in the technical hybrid system. *Patent UA; A61N1/326, G01N33/00, C12Q 1/02*. Priority: 14. 12. 2018, u201812442. (In Ukrainian).
177. *Klyuchko O. M., Biletsky A. Ya., Lizunov G. V., Shutko V. N.* Method for application of the system of large-scale monitoring of bioobjects with possibility of their radar control. *Patent UA; G01N33/00, G01S13/88, C12N 15/00*. Priority: 14. 12. 2018, u201812444. (In Ukrainian).
178. *Klyuchko O. M., Biletsky A. Ya., Lizunov G. V., Piankova O. V.* Method of application of biosensor test-system with databases. *Patent UA; G01N33/00, C12Q 1/02*. Priority: 17. 01. 2019, u201900476. (In Ukrainian).
179. *Klyuchko O. M., Biletsky A. Ya., Lizunov G. V., Piankova O. V.* Method of application of monitoring system with biosensor and databases. *Patent UA; G01N33/00, C12Q 1/02, G06F11/20*. Priority: 17. 01. 2019, u201900476. (In Ukrainian).

ЕЛЕКТРОННІ АВТОМАТИЗОВАНІ РОБОЧІ МІСЦЯ ДЛЯ БІОТЕХНОЛОГІЇ

О. М. Ключко[1], *А. А. Аралова*[2], *Н. І. Аралова*[2]

[1]Інститут експериментальної патології, онкології та радіобіології ім. Р.Є.Кавецького НАН України, Київ
[2]Інститут кібернетики ім. В.М. Глушкова НАН України, Київ

E-mail: kelenaXX@ukr.net

Метою роботи було проаналізувати матеріал щодо розроблення електронних автоматизованих робочих місць для створення більш досконалих зразків у біотехнології. Було застосовано методи програмного, математичного, а також імітаційного моделювання. Обговорено інформацію щодо кількох прототипів електронних автоматизованих робочих місць, створених для біології та суміжних галузей в Україні протягом останніх 25–30 років. Подано результати створення декількох автоматизованих робочих місць, розроблених авторами. Узагальнено одержані дані та розроблено комплекс рекомендацій щодо їх практичного використання.

Ключові слова: електронні автоматизовані робочі місця, біоінформатика, електронні інформаційні системи, бази даних.

ЭЛЕКТРОННЫЕ АВТОМАТИЗИРОВАННЫЕ РАБОЧИЕ МЕСТА ДЛЯ БИОТЕХНОЛОГИИ

Е. М. Ключко[1], *А. А. Аралова*[2], *Н.И. Аралова*[2]

[1]Институт экспериментальной патологии, онкологии и радиобиологии им. Р.Е. Кавецкого НАН Украины, Киев
[2]Институт кибернетики им. В.М. Глушкова НАН Украины, Киев

E-mail: kelenaXX@ukr.net

Целью работы был анализ материала по созданию электронных автоматизированных рабочих мест для организации более совершенных образцов в биотехнологии. Использовали методы программного, математического, а также имитационного моделирования. Обсуждена информация о нескольких прототипах электронных автоматизированных рабочих мест, созданных для биологии и смежных отраслей в Украине за последние 25–30 лет. Представлены результаты создания нескольких автоматизированных рабочих мест, разработанных авторами. Обобщены полученные данные и разработан комплекс рекомендаций по их практической реализации.

Ключевые слова: электронные автоматизированные рабочие места, биоинформатика, электронные информационные системы, базы данных.