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THE USE OF THE COMPLEX ACTION OF ENVIRONMENTAL FACTORS IN THE PROCESS OF SPACE COLONIZATION

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The article analysis the formation of adaptive responses of the human body to changes in climatic factors. The results of this analysis are recommended for use in the design of isolated artificial self-regulating ecosystems in the process of space colonization. Modern orbital space settlements are not self-sufficient. Orbital space stations are completely dependent on logistical connections with the Earth and require huge resources to maintain the conditions for human existence. Logistical connections will become more difficult as the distance between the Earth and the newly formed colonies will increase during space colonization. The development of our civilization and raising the level of its protection is impossible without progress in the practical modelling of ecosystems and the development of ecosystem theories. We tried to build isolated self-sufficient ecosystems using the method of miniaturization and a simple combination of environmental factors. Such attempts have failed. Ecosystem modelling with simple miniaturization has led to the failure of many ambitious projects, including such a large-scale as "Biosphere 2". We need to take a systems approach to create a self-sufficient isolated ecosystem. The application of a systems approach will allow to model the complex interaction between the components of the created ecosystem. We must take into account the parameters of individual factors and the peculiarities of the interaction between them when designing artificial isolated ecosystems. Adaptation to one of the environmental factors is often highly dependent on another factor. We need to conduct a series of studies where several indicators will change in a controlled way, while the rest remain stable, to establish a complete picture of the body's interaction with the environment. Creating and conducting research on isolated artificial ecosystems is one of the most objective and fundamental methods of testing the level and depth of our ecological knowledge. *Key words***:** adaptation, biorhythms, space expansion, cardio-respiratory apparatus.

Використання комплексної дії факторів середовища в процесі колонізації космосу. Онищук І.П., Хом'як І.В.
Стаття присвячена аналізу формування адаптативних відповідей людського організму на зміну показників кліматичних факторів. Результати цього аналізу рекомендовано застосовувати під час проектування ізольованих, штучних, самодостатніх екосистем в процесі колонізації космічного простору. Сучасні орбітальні космічні поселення не є самодостатніми. Вони повністю залежні від логістичних зв'язків із Землею та вимагають величезних затрат ресурсів для підтримання оптимальних умов існування. Під час колонізації космосу логістичні зв'язки ускладняться, через зростання відстаней між Землею та новоутвореними колоніями. Таким чином, розвиток нашої цивілізації та підняття степені її захищеності утруднений без прогресу в практичному моделюванні екосистем. Побудова ізольованих самодостатніх екосистем неможлива методом мініатюризації та простої комбінації факторів середовища. Це стало причиною провалу багатьох амбітних проектів, в тому числі такого масштабу як «Біосфера 2». Для створення самодостатньої ізольованої екосистеми, потрібно застосовувати системний підхід, який дозволить змоделювати складну взаємодію між компонентами, створюваної екосистеми. Під час проектування штучних ізольованих екосистем необхідно враховувати не лише параметри окремих факторів, а й особливості взаємодії між ними. Адаптація до одного із факторів середовища часто має сильну залежність від іншого фактора. Для встановлення повної картини взаємодії організму із середовищем, необхідно проводити серії досліджень, де контрольовано мінятимуться кілька показників, тоді коли решта залишаються сталими. Ще одним важливим чинником є механізми пов'язані із біоритмами людини, та системами сигналів, які їх запускають. Створення та проведення досліджень ізольованих, штучних екосистем є одним із найбільш об'єктивних та принципових методів перевірки рівня та глибини наших екологічних знань. *Ключові слова:* адаптація, біоритми, космічна експансія, кардіо-респіраторний апарат.

Introduction. In the summer of 1950, Nobel laureate Enrico Fermi asked the famous question at the Los Alamos Laboratory coffee shop «Fuller Lodge». He asked, "Where is everyone?" It was an informal discussion with Edward Teller, Emil Konopinsky and Herbert York on "Are we the only intelligent and technologically advanced civilization in the universe." Thus arose the phenomenon of The Great Silence or Fermi Paradox, which gave rise to many years of discussions and many projects to find intelligent life in the universe. However, the long search was not successful. There are many hypotheses about the reasons for lack of contact with other civilizations. The results of research on the history of our planet and outer space indicate the superiority of one hypothesis over another [6]. Space is not life-friendly [18]. There are many phenomena in outer space that can destroy all living things on a gigantic scale [23].

There are many places in outer space where life can occur, but there are very few places where life has a great chance of being preserved so that life can evolve in the mind and form civilizations. Our planet is very unique [22]. We are very fortunate that we were not destroyed in one of the many disasters of the past. The risks of death in such disasters have not disappeared.

The biosphere is not able to protect itself from the great dangers of cosmic phenomena. Evolutionary mechanisms of protection against dangers are made only when there are often recurring phenomena are not beyond death area. Low-organized organisms better withstand harsh environmental conditions and biota does not have energy commensurate with the sources of space catastrophes [24]. We can see three survival strategies in the universe: "hardness", "quantity" and "plasticity" [5]. The first two strategies are not able to save the life of the planet from deadly space phenomena [19]. To save the planet requires a more selective and predictive response to the threat and space-scale energy [18]. This can be achieved through the use of the "plasticity" strategy. An intelligent creature capable of knowing and consciously changing the world is the only hope for increasing the chances of the biosphere surviving. Human is the only creature on planet Earth that can be the main tool for survival and knowledge of the world [14].

We can imagine all the accumulated knowledge as a sphere. On the one hand, the larger the volume of the sphere, the larger the surface, which is a zone of the unknown world. On the other hand, the sphere of knowledge must grow evenly. Often successes in one field of knowledge allow to succeed in another and stagnation in one science slows down development of several other sciences.

Our field of knowledge has three vectors of expansion [17]. The first vector is the study of the infinitely large. This direction is headed by astrophysics. The second vector is the study of the infinitesimal by quantum physics. The third vector of research is the study of complex systems. The latter direction covers many sciences from ecology to psychology and sociology. Each direction of expanding the sphere of knowledge requires the improvement of research methods, science instrument and the expansion of the study area. If we move research further into space, we get two big benefits [11]. On the one hand, it is one of the three key direction for expanding the sphere of knowledge. On the other hand, outer space is the source of the greatest threats to our existence.

Analysis of recent research and publications. We may have many limitations that slow down the expansion of the "sphere of knowledge" when we explore outer space from the surface of the planet. Space catastrophes will not wait until we can stop them on the surface of the planet. We need to move our research tools into the depths of outer space for we can best explored it. The development of robotics will soon not be able to meet our needs and match the capabilities of a trained team of researchers. We will move step by step further from the home planet, from scientific bases in orbit to the Moon and the outskirts of the Solar system. This movement into the depths of space will increase our knowledge of the universe and stimulate the development of technology, which will increase our ability to confront space threats and increase our chances of survival. We failed when we implemented ambitious projects to create miniature self-sufficient and functional copies of our biosphere [16]. Our knowledge of local and global ecosystems is very limited [1, 2, 3, 7, 8]. We cannot yet create an isolated, self-regulating natural system where a group of people will feel comfortable. We need to conduct comprehensive environmental and physiological research on the effects of environmental factors on the human body to overcome this important problem.

Purpose and objectives of the study: to study the ecological effects on the complex reflex mechanisms of thermoregulation in temperate climates and the course of adaptive thermoregulation in humans. We set the tasks: 1) Investigate the features of regulation of temperature homeostasis and factors of body temperature stability. 2) Investigate the features of adaptive reactions to temperate climates through the process of thermoregulation: chemical, physiological. 3) Describe the physiological significance of climatic factors of the environment. 4) Model the complex impact of environmental factors. 5) Develop recommendations that take into account the complex action of factors in an isolated artificial environment [21, 15].

Materials and methods of research. Data from the monitoring of the physiological condition of the participants of the experiment are the materials of the study made in the period from January to August 2020 [4]. The age of the participants in the experiment was from 19 to 21 years. The group was selected according to anthropometric parameters. age, body weight, height, excursion and chest circumference (normal and deep breaths). We studied the functional state of the human cardio-respiratory apparatus in conditions corresponding to the temperate climate in the warm season and day and in conditions of high humidity and temperature. We studied body temperature, heart rate, blood pressure and respiratory rate. Under normal circumstances, such studies were performed daily at 7:00 am.

Research results and discussion. The «Biosphere 2» project was the first large-scale experiment to move a group of people into an isolated artificial ecosystem. It was a 1.27-hectare facility located in Oracle, Arizona. The researchers divided the area into seven zones that mimicked the main biomes of the Earth. Spontaneous reduction (miniaturization) of the number of structural elements of ecosystems does not give the expected effect [24].

Our planet has gone through several global crises, during which there has been a reduction in species. This triggered a chain of changes that further reduced the number of species. The system «Biosphere 2» system can exist for a long time, only if available energy and climate control. The initial species composition of the territory could not be preserved. Only a limited number of primitive species will be preserved here, and it would take tens of millions of years to restore the original biodiversity. This is exactly what happened after the great catastrophes on our planet. The scale of the planet is many times larger than the territory of the project, so there was many times more material for evolution. In such conditions, human existence would be unlikely, so the experiment was doomed to failure.

Participants in the experiment complained of discomfort for many reasons – from constant hunger to socio-psychological problems. The newly created ecosystem began to rebuild and began to resemble the ecosystems of some remote oceanic islands. During this restructuring of connections in ecosystems, many changes in the numbers of individual species began to occur. Some species aggressively reproduced and displaced neighbors and others began to disappear. The project came under pressure from unscrupulous journalist, but the main reason for stopping the experiment was mikroclimate changes. We can see that the level of oxygen in the air decreased to 14.5%, there were significant fluctuations (daily and seasonal) of carbon dioxide content, increased humidity and formed condensation [13]. Increased moisture causes the strongest maladaptation reaction of the project participants. Increased humidity in combination with other factors often reduces the adaptive capacity of species [20].

We combined changes in humidity and temperature in our experiment. The results of the experiment allow us to observe a complex systemic response of the body to temperature fluctuations. Several factors influenced adaptive responses simultaneously. Combinations of different factors influenced the body's response along with biorhythms: circadian, selenium and circannual [9, 10, 12]. For example, in January, the morning average body temperature of the subjects was 35.87 °C, day – 36.32 °C, the average temperature response – 0.41 °C. The value of the change in the average temperature response in April is 0.22 °C at a morning temperature of 36.56 °C and a daytime temperature of 36.73 °C, respectively. In July, at an average monthly temperature of 25 °C, the temperature response of the subjects was 0.12 °C and has the lowest values (morning – 36.78 °C, day – 36.90 °C).

We observed a similar relationship within other measured reactions. In January, the morning average respiratory rate – 15.7, daily – 1 6.3, respectively, the average response of the respiratory system 0.6. The value of the average respiratory rate reaction in April was 1.9 at a morning temperature of 16.6 and a daytime temperature of 18.4, respectively. In July, at an average monthly temperature of 24 t °C, the average respiratory rate response in the subjects was 4.8 and there is an increase in this indicator at an average respiratory rate of 18 in the morning and 22.9 in the day). In January, the morning average heart rate was 72.4, the daily average was 74.3, and the average heart rate response was 2.7. The value of the average heart rate response in April 2.8 at morning temperature – 75.1 and day – 77.9, respectively. In July, at an average monthly temperature of 24 t °C, the average response of heart rate in the subjects was 7.7, ie the amplitude of fluctuations in the subjects increases, which can be explained by individual reactions to temperature increase during the day. The average heart rate was: in the morning heart rate – 77.9; in the afternoon heart rate – 85.9; average heart rate response – 7.7.

An increase in ambient temperature during the day leads to a partial increase in blood pressure in the vessels in the warmer months of the year. It is a reflex reaction of the vascular center of the medulla oblongata to excess heat in the body, because physical heat transfer is difficult. The vessels of the skin are most effective in responding to temperature fluctuations in the environment by changing their tone. It is the result of complex reflex temperature adaptations too.

In January, the morning blood pressure of the subjects was 116.6 / 72, daily, respectively, 114.4 / 73.5, the average reaction values are – 2.2 / 1.5. In April, the morning – 118.2 / 74.5, day – 120.7 / 76.7, the reaction – 2.5 / 1.9. In July, the morning – 122.6 / 77.9, day – 125.4 / 80.5, the reaction – 2.8 / 2.5.

Main conclusions. We cannot build isolated self-sufficient ecosystems using miniaturization and a simple combination of environmental factors. We must to use a systems approach. It will simulate the complex interaction between the components of the created ecosystem.

When designing artificial isolated ecosystems, we must take into account the parameters of individual factors, the interaction between it, human biorhythms and signals that trigger it.

Creating and conducting research on isolated artificial ecosystems is one of the most objective and fundamental methods of testing the level and depth of our ecological knowledge.

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