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# PROSPECTS OF THE BIONIC APPROACH IN ARCHITECTURE AND ENVIRONMENTAL DESIGN

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**Abstract.** This article examines the contemporary challenges taking place in the fields of architecture and environmental design as they emerged as being under biodesign, and explores the prospective scope of the bionic approach. The advancement of science and technology brings new requirements and challenges that give rise to new dimensions of professional and artistic collaboration between architects and designers, green architecture, and the formation of new environmental spaces. It defines as well the significant role of bio-design in the context of technogenic society. There is also a great emphasis put on adopting a systemic view for the approach in the design of buildings that cater to environmental, social, demographic, and economic needs. This also introduces specific requirements for “green” architecture in this essay is approached through the lens of the modern practice of construction and design across the globe where bionic and “green architecture” ideas are imposed to foster an interdisciplinary way of working. This is to increase efficacy, comfort, and environmental friendliness of the architectural space, object design, setting, and even the ecological condition of space. The “green” architecture pointers have undergone an analysis and in-depth review of the bionic forms integrated into green architecture endeavors. New biodesign techniques and green innovations have been the primary language in the construction industry giving rise to superseding and increased precision in the architectural solutions and designs that utilize international standards.

**Keywords:** design, bionics, bionic forms, bio-design, "green" architecture, an architectural environment, integrated approach in design.

**Relevance of the study.** Nowadays it is difficult to imagine the formation and creation of a person's living environment using only architectural and artistic techniques, without the widespread use of the latest methods, which allow specialists to reflect fully the attitude of an architect or designer to the natural environment and human living space. New requirements and tasks of modern society and culture open up new horizons in architectural and environmental design, and creativity in general. Thanks to informatization modern architects have an opportunity to constantly adjust their work to the latest world achievements in the field of culture and technology. The alienation of man from architecture has become an obvious deep problem of architectural activity at the level of the author-architect, the consumer-addressee and on the level of the work, in which one feels "deadness", "detachment" from the system of natural-humanistic needs and conditions.

The replacement of the biosphere with the technosphere in the future led to the destruction of many national ecosystems, and actions of several negative factors, including chemical, biological, and physical pollution [1, p. 126]. The climate crisis causes significant problems with electricity and the natural environment in many technogenic societies. Very often, technological processes cause high emissions, disrupt biosystems, and negatively affect the ecological state of the environment and nature. In the context of evaluating the quality of buildings, the rating approach is increasingly being introduced in the international systems LEED (Leadership in Energy & Environmental Design), and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), promoting a fundamentally new approach

to design and construction, taking into account the use of progressive "green" technologies [2, pp. 126-127]. These components are effective in ensuring the creation of comfortable, healthy, and energy-efficient spaces for people to live, work, and relax [3, pp. 140-141].

Therefore, in modern architectural practice, it is very important to use principles aimed at ensuring energy saving and environmental protection. The use of achievements in the sphere of bionics and biodesign is an important approach to solving the problems of climate change and the lack of natural resources in the era of growing environmental awareness. The integration of the environmental approach into modern architectural practice can create a comfortable living space for people and reduce the negative global impact on the planet. However, bionical and ecological principles are not implemented effectively in modern architectural construction and environmental design in many cases, because of socio-political, demographic, and economic factors.

The rapid development of construction technologies and new materials brings modern architecture to a new level of quality. And it is essential to recognize the creative contribution of other professionals in this transformation. The principles of "green" construction aim to achieve not only ecological but also aesthetic harmony between the architectural, human living environment, and the nature. That`s why, the professional and creative activities of designers, in particular, specialists in the direction of both architectural objects and the field of environmental design, play an important role in the development of modern architecture. Especially biodesign can be a key element, introducing natural principles into the process of designing and creating architectural objects in modern architecture. Biodesign of architecture, objects, and the environment is based on the study and analysis of natural forms, structures, and processes, which allows the creation of effective and environmentally sustainable solutions. The designers, inspired by nature, actively use the principles of bionics to develop innovative architectural concepts that are maximally adapted to the environment [4].

**The problem** considered in the article is obvious: evaluate and confirm the potential and prospects of using the bionic approach in modern architectural design. In the context of rapid urban development, increasing environmental challenges and requirements for sustainable development, the issues of efficiency, functionality, and environmental sustainability of architectural objects are becoming more relevant and even crucial. However, it is necessary to determine how well the bionic approach can fulfill these requirements and solve the challenges of modern architecture and environmental design.

**Analysis of the latest research and publications.** The problems of modern architecture are covered in the works of M.A. Dutsev, L.A. Motorina, K. Frampton, etc. L.L. Musin's scientific research shows, that "green" technologies and innovations are considered engines of economic growth: constantly changing and developing dynamically. Researches and projects of outstanding architects L.A. Sullivan, F. Wright, Le Corbusier, N.A. Foster, A. Aalto explore the interaction and connection between nature and architecture, the principles and forms of eco-architecture. The basic works of Yu. Lebedev analyze the systems, processes, and natural materials that will ensure compatibility and harmony between the architectural and natural environment. A. Tetiora's scientific works are devoted to the study of the natural principles of the structure and functioning of living organisms, opening up new directions for the search for effective forms and structures of buildings in accordance with the requirements of urbanism. Architectural theorists B. Chum and P. Eisenman examine the "interrelations between the constructed building and the world", and define destructive tendencies in the field of construction. New Zealand doctor E. Charleson focuses on multifunctional and aesthetic considerations in his book "Structure as Architecture". From his point of view, the structure becomes an indispensable and comprehensive architectural element. It is called upon to change the interpretation of the structure as a "purely soft utilitarian element" [5].

Research in the field of bionics and the bionic approach in architecture and environmental design are conducted by various organizations and institutions, including many universities around the world. These universities have departments or laboratories which are specialized in research in

architecture, design and bionics, for example, the Massachusetts Institute of Technology (MIT), the Swiss Federal Institute of Technology (ETH Zurich), and the University of Cambridge. There are also specialized research centers and laboratories studying the biodesign of the architectural environment, such as the Biomimicry Institute in the USA or the Centre for Biomimetic & Natural Technologies in the UK. However, despite the wide range of scientific research issues, the topic of "Bionic direction in architecture and environmental design" remains relevant and requires further careful study. The conceptual basis and state policy for the implementing of biodesign principles in "green architecture" in each specific case depend on climatic conditions, socio-political, economic and environmental factors, cultural traditions and preferences and the problems of the development of a technogenic society.

**The aim** of the research is to analyze and prove the prospects of the bionic approach in architecture and environmental design, taking into account modern trends and challenges. The research will be focused at identifying the potential of bionics as an innovative method in architectural design, and assess of its applicability for creating sustainable, ergonomic and aesthetically attractive architectural projects. Therefore, by analyzing the bionic concepts in architectural practice, this study can contribute to a deeper understanding of the role and significance of the bionic approach in modern architecture and environmental design. It can also determine the prospects of its future development.

**Research objectives:**

• review scientific papers, publications and studies devoted to bionics in the context of architecture and design to substantiate the prospects of this direction;

• analyze and identify compliance with the principles of bionics of modern trends in architectural design, as well as identify problems and challenges that can be solved using the bionic approach.

• study examples of practical application on samples of specific projects and their implementation, where bionic principles were used in architecture and environmental design, in order to identify their effectiveness, advantages and disadvantages.

• evaluate the potential and prospects of the bionic approach in architecture and environmental design, taking into account the requirements of modern times, including sustainability, energy efficiency, comfort and aesthetics of the created objects.

• make general conclusions about the significance and prospects for the development of the bionic direction in architecture and environmental design.

**Presentation of the main material.** The era of technogenic society and globalization force us to perceive the world in a new way and look for new ways of understanding it. There are many international environmental organizations in the world that conduct various scientific studies of the impact of human activity on the climate, atmosphere, hydrosphere, soil, flora and fauna, forecast earthquakes and tsunamis, as well as studies of biological and genetic consequences, environmental pollution. International organizations allow uniting the environmental activities of interested states regardless of their political positions, highlighting environmental problems among other problems. The leading role in the organization and development of international cooperation in the field of environmental protection is assigned to the United Nations and its specialized agencies. Such cooperation is an integral part of the UN activities to maintain peace and security solve current economic, social and other global problems. The United Nations is the coordinator of all forms of environmental cooperation between states.

In 1983, the UN convened the World Commission on the Environment for the first time to discuss environmental issues at the global level. The General Assembly determines the main directions and principles of the international community's environmental policy, organizes international UN conferences on current environmental issues, develops recommendations and drafts international conventions on relevant issues, creates environmental organizational structures and takes other measures to develop multilateral cooperation, and bilateral cooperation in the environmental sector [6]. However, solving the acute problems of the environmental crisis remains

relevant. Many factors negatively affect the environment: industrial production processes, overloading the transport system, reduction of wildlife habitats, and pollution of water resources. The construction sector is responsible for 40% of air and drinking water pollution, climate change and the volume of waste in landfills. Therefore, strict standards and certifications began to be introduced in the architectural sphere. The first standard was The Leadership in Energy & Environmental Design (LEED), developed back in 1993. Subsequently, many new certification standards emerged, such as the British BREEAM, the American WELL and Fitwel, and others.

Architecture and design, albeit slowly, are still moving towards a "green path". Therefore, an important trend in the development of modern construction is "green" architecture.

The vector of development of "green" architecture is formed by its main principles:

• ecological balanse between natural and artificial components;

• adequacy of the constructive and volumetric-spatial solutions of architectural objects with geomorphology,

• use of the bionic methods (properties, structures, forms and functions of living nature, which are used in architectural objects and design forms.);

• usage of biotechnologies that effectively improve the microclimatic parameters of the living and natural environment;

• artistic and aesthetic qualities of the image of the architectural environment;

• introduction of a natural component into the structure of the building (parks, gardens, plants, artificial reservoirs, etc.);

• compliance with nature (taking into account the anatomical, physiological and psychological characteristics of human nature);

• taking into account the risks of natural, climatic and man-made nature.

It should be noted that "green" technologies are aimed at solving important environmental and economic problems of modern urban space. The main task of "green" technologies is the improvement and use of existing (natural reservoirs, forests, parks, gardens, green areas, etc.), or the creation of new green areas to harmonize human living space. The bionic approach to architecture and design emphasizes the importance of close interaction between various specialists, including design engineers and designers, to create unique and innovative architectural solutions [7, p. 156]. Without the active participation of engineers and designers involved in the creative process of design and construction, it is impossible to imagine the construction of unique architectural buildings and structures that require the creation of individual methods and approaches to solving a range of complex problems. The process of applying bionic concepts may be incomplete and ineffective. Specialists play a key role in turning bionic ideas and concepts into real technical solutions. They have expert knowledge of the materials, designs and technologies for creating innovative architectural forms and structures inspired by nature.

In the construction of "green" architecture, durable, lightweight and elastic materials are used that are safe for human life and the natural environment, resistant to the corresponding climatic conditions, providing a high level of fire resistance, thermal and sound insulation. It is the implementation of the principles of "green" architecture that allows us to create the necessary conditions for the protection and preservation of the natural environment [8]. Designers, in turn, attach aesthetic significance to projects, helping to translate biological beauty and functionality into architectural forms that will be attractive and convenient for users. This includes adapting natural concepts to specific conditions and project requirements, developing innovative solutions to solve a range of complex problems, as well as taking into account aesthetic and functional aspects. Thus, active interaction and cooperation between different specialists is a prerequisite for the successful implementation of bionic ideas in architectural practice. It is important to understand that biodesign is not only improving the appearance of buildings, but also optimizing their functionality, energy efficiency and convenience for people. Biodesign principles take into account the biological needs of living beings, ensuring the creation of architectural spaces that promote human health and well-being.

Innovative technologies such as 3D printing and biomimicry help designers translate biological concepts into real architectural objects. Professional architects and designers not only monitor the aesthetic aspects of the spaces they create, but also consider their impact on ecosystems and biodiversity. By collaborating with ecologists, biologists and engineers, architects and designers working in the field of biodesign create unique and integrated architectural solutions that promote the sustainable development of cities and society as a whole. The bionic approach to architecture and environmental design opens up new horizons for modern architecture, introducing elements of innovation, beauty and harmony with nature [9].

Biodesign and the principles of "green" architecture stimulate the introduction of not only biomaterials into construction, but also recreational natural zones and biosystems. Plants in their natural environment have developed unique properties to withstand mechanical forces, and temperature fluctuations and resist pests and diseases. The structural features and properties of some plants or other living organisms help architects solve important environmental, socio-economic, structural-technological problems, and other issues of modern construction. Construction materials and designer structures created on the basis of microalgae and fungi are characterized by strength, lightness, elasticity, and are safe for the environment. Biopolymers (polylactide–PLA), used for insulation and coating, are environmentally friendly because they are made from plant resources. The use of materials with a neutral carbon footprint is an important aspect in construction. For example, bamboo is actively used in the construction of China and Japan which is characterized by high strength, flexibility, durability, and a low carbon footprint. For example, the main concept of the Bamboo Gate Park in 2024 (Kengo Kuma and Associates) is to prevent disasters in the city of Kurashiki, which often suffers from large-scale destructive floods and downpours (Fig. 1).

Fig. 1. Mabi Reconstruction Disaster Prevention Park – Bamboo Gate, 2024. Kengo Kuma & Associates

The building combines two main functions as an emergency shelter and a center of social support for citizens [10] with modern innovations in architecture. Wide massive beams and cornices create natural ventilation, protect from the sun and rain. The building has the shape of two cylindrical volumes, united by a wave-shaped roof. The architectural forms and silhouette of the building resemble a gate and are organically integrated into the local natural landscape. The project transformed the territory of the destroyed dam into a place with magnificent views. The cladding of the facades and decoration of the interiors of the building uses a traditional building material for the region – bamboo, which is a symbol of the invincibility and resilience of the Japanese people. The main function of the building is not only to withstand the unpredictable consequences of natural disasters, but also to create comfortable living conditions and protect local residents in adverse natural conditions.

The interaction of various ideas, concepts, creative methods, modern technologies, which form the basis of architectural ideas, allows to obtain unique architectural and design works. As a result of

the creative symbiosis of specialists of different professions, fantastic "green" buildings are born. Thus, according to the project of the outstanding Italian architect Stefano Boeri "The Cedar Tower" (The Tourdes Cèdresin Lausanne) in 2015 the construction of a 36-storey tower in Lausanne began, the height of which will reach 117 m (Fig. 2).

Fig. 2. The Tourdes Cèdres in Lausanne, 2015

The main goal of the project is to combine the comfortable conditions of a housing complex with the beauty of life in nature, the maximum integration of the living environment of people into nature. Therefore, the project involves the creation of a residential building, the space of which will be filled with various green spaces (18,000 plants, 6,000 bushes on an area of 3,000 m2) [11]. Buro Happold has developed unique prefabricated concrete structures in the form of loggias, terraces and boxes. These cantilever panels will be connected to the reinforced concrete structure of the tower frame, in which they plan to plant vegetation, most of which are well adapted to the climatic conditions of the region. Particular importance in this biodesign concept is given to coniferous trees, in particular cedars. The tower will form the image of a "vertical forest" of evergreen trees. It is planned to plant 100 cedar trees of four species on the tower, as they effectively absorb carbon dioxide, purify the air and kill harmful microbes thanks to phytoncides. The life cycle of a cedar can last more than 2000 years, and the height is up to 50 m. The tree has the ability to adapt to extreme climatic factors, to survive in the most severe natural conditions. Therefore, this tree has long been considered sacred and has become a symbol of spiritual strength, rebelliousness, longevity. The green design of the building implies the use of sustainable technologies, such as solar energy, natural ventilation, rainwater collection, energy saving, etc. In addition to comfortable apartments and offices, the building is planned to accommodate a gym to maintain people's physical health. A panoramic restaurant is also designed, which will allow residents and guests to enjoy not only delicious dishes, but also beautiful local views from a bird's eye view [12].

Another successful example of the modern development of green architecture and biodesign is the energy-efficient innovative conference center in Hangzhou (China) [13]. First, in 2015, the Cloud Town Conference Center was built in the West Lake area of Zhejiang Province (Fig. 3). But over time, they decided to expand the complex by adding an Exhibition Center. The authors of the project abandoned the principle of "inaccessible height". On the contrary, they partially dipped the building structure (the ceiling height reaches 9 m) under the ground at a depth of 3 m. The forms of the building are hidden under a green roof, on which there are running tracks, sports fields and courts. The biodesign of the roof harmoniously fits into the natural landscape of the city park.

Fig. 3. Conference Center in Cloud Town, 2015. Hangzhou, China

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The green ceiling area of the Exhibition Hall is a favorite recreation area for residents and visitors of the city. The project laconically expresses the idea of maximum integration of a public building with the natural environment. The trends in the development of architecture in China are strongly influenced by rapid population change and stress associated with the way of life in cities. Therefore, the architecture is maximally integrated into the park environment (Fig. 4), and green areas are transformed into urban landscapes to improve the quality of urban areas and districts [14]. There are many parks in the city of Changzhou, the biodesign concept of which is carefully thought out. The parks cover a huge variety of plantings that form a unique recreational natural zone of the city. The types, shapes, sizes, and features of the plantings are determined by the concept of national landscape design traditions and create a sense of harmony and incredible beauty of China's nature. Huge lotus water lilies magically cover the surface of the water element of the lakes (Fig. 5).

Fig. 4. Sports complex in the park of Hangzhou, 2021Fig. 5.Park in Hangzhou

The park space is filled with small architectural forms, such as wooden and stone bridges, various gazebos. Well-groomed living fences made of tree peonies, boxwood, and other bushes that fill the air with an excellent aroma are used to separate the zones. With the help of a system of supports and cables, the trunks of tall trees are aligned and secured, and the shape of their crowns is corrected by the process of formative pruning. An interesting fact is that specialists are constantly solving the complex problem of the local soil characteristics, which must be constantly loosened, enriched with a structure of sand, peat, limestone. However, the incredibly fabulous view and excellent conditionof the Changzhou Park clearly demonstrate that all difficulties can be overcome. By the way, significant government investments are allocated to support the park, helping to maintain not only the park, but also the developed infrastructure and communications of the cultural center. In combination with the

requirements of local development, cooperation is stimulated on the principle of "bottom up", and includes the government, enterprises and residents" [15].

In modern architectural design, the role of biodesign specialists, ecologists, who take creative part already at the stage of defining the basic concept of the future building, such as theaters, airports, exhibition galleries, etc. is very important. Modern embodiment of the bionic direction in architecture can be observed in the Netherlands (NMB Bank board building), Montreal (World Exhibition Complex building), Australia (Sydney Opera building), Japan (SONY skyscraper and fruit museum in Yamanase). There is also a tendency to introduce biodesign in the formation of interiors for public purposes and office premises. Widely known examples of the use of biodesign in the interior are the metro stations: Stockholm – "Rinkeby", "Stadium" (architects E. Halek, E. Pappart), Brussels metro station "Roy Baudouin" F. Dessel. Effective creative cooperation between architects and biodesign specialists was expressed in the implementation of the Commerzbank Tower project, built in 1997 in the center of Frankfurt am Main (Fig. 6).

Fig.6.CommerzbankTower, 1997. Frankfurt, Germany

The Commerzbank Tower is one of the tallest buildings in Europe (53 floors) and the first ecological office. The main goal of the project is to study the characteristics of the office environment and develop new ideas for its ecology [16]. The concept of the project is based on trust in natural lighting and ventilation systems, which required combining the central atrium, around which nine four-level winter gardens and office spaces are located, into one organic whole. This allows company employees to manage the environment themselves (the windows of the premises can be opened by office employees) and spend time relaxing in comfortable conditions, which positively contributes to the rapid emotional and physical recovery of employees. The height of the glass walls of the winter gardens, located in a spiral around the frame structure of the tower, reaches 15 m. On each side of the building's façade there are three gardens with glass walls 15 m high. Plantings are located in a spiral around the skyscraper, having the shape of a rounded equilateral triangle 60 m wide. The unique steel frame structure of the tower without the use of columns allows for the creation of a 34-meter space for a garden. The biosystem of the gardens effectively maintains the purity and humidity of the air, filling it with a pleasant aroma. The biodesign concept of the gardens was carefully thought out taking into account the climatic conditions and the irrigation and nutrition system of the plants. Since 2008,

only green energy and environmentally friendly materials have been used for the functioning of all systems and communications of the Commerzbank Tower [17].

Another example of the implementation of the concept of "green architecture" is the Shanghai Tower (China), which is 632 m high (the tallest tower in the country) (Fig. 7). The construction of the building lasted from 2008 to 2013. Famous Spanish architects M.-A. Cerver and J. Ploz, active fans of bionics, began to study "dynamic structures" in 1985, and in 1991 they organized the "Society for the Support of Innovation in Architecture". A group under their leadership, which included architects, engineers, designers, biologists and psychologists, developed the "Vertical Bionic Tower City" project. The project of the tower city, designed for one hundred thousand people, is based on the "principle of tree construction". The original design solution of the building is a transparent second shell, enveloping the entire building and forming a ventilated atrium. The atrium space regulates the temperature between the interior and exterior spaces well: it heats the cold outside air in winter and reduces the concentration of heat from the inside in summer.

Fig.7. Shanghai Tower, 2013. China, Shanghai

The tower structure consists of nine cylindrical bodies located one above the other and surrounded by a double façade. The nine atriums of the façade consist of 20 thousand glass panels of unique curved shapes. The introduction of the spiral design made it possible to reduce the consumption of building materials by 25%. The Shanghai Tower uses 40% less water and 21% less energy than other similar buildings. Wind turbines are located on the top floor of the tower, fully satisfying the needs for external lighting and consumed electricity. The twisted shape of the skyscraper allows collecting rainwater for further use, and panoramic glazing helps save electricity. The building also has a combined cooling and heating system. All these design methods help to reduce carbon dioxide emissions annually, as well as reduce energy consumption by 21%. Gardens are located between the internal and external cladding of the tower building [18].The combination of biodesign principles, energy conservation and environmental friendliness are embodied in the architectural solution of the Apple Inc. Headquarters. "Apple Park", 2017, California, USA. (Fig. 8). The territory of Apple Park occupies an area of 708,200 m2. The building fits harmoniously into the natural environment of the meadow landscape and operates entirely on renewable energy sources. Thus, 75% of the building's electricity needs are provided by solar panels on the roof, 25% are

provided by Bloom Energy Server fuel cells running on biofuel. The complex also does not need a ventilation system, since Apple Park is a glass shell that "breathes", and air circulates freely inside the building. Apple Park is equipped with a forced air return system and chambers. Recycled water is used to irrigate the garden and drought-resistant plants. The building has a curved glass façade and a canopy that protects the surface from sunlight; it does not require heating or cooling for nine months of the year.

Fig. 8.ApplePark, 2017. California, USA.

The building's design is also characterized by a unique precast concrete frame system. The interior design of the building is formed by an innovative system of floors and ceilings made of hollow slabs, providing rigidity and elasticity during seismic vibrations. 175 acres of the territory are occupied by green spaces – more than 9,000 trees. The landscape design helps new employees navigate the park space. The cafe is capable of serving 4,000 visitors and uses products grown on the park's territory [19].

Fig. 9.BoscoVerticale, 2014. Milan, Italy

The BoscoVerticale complex in Milan (Italy), built in 2014, is also a successful example of the implementation of the principles of "green" architecture (Fig. 9). The territory where the project was implemented was one of the last undeveloped places in Milan due to poorly developed infrastructure and abandoned areas. Bosco Verticale is formed by two high towers equipped with green spaces (more than 17 thousand trees and plants). The vertical forest of buildings contributes to the formation of an urban ecosystem, enriches the flora and fauna in the city center.

The created green landscape protects from solar radiation, increases the level of air humidity and oxygen production, absorbs noise pollution, and purifies the air. The project is aimed at creating an energy-efficient infrastructure while minimizing the impact on the environment and the ecosystem. The green spaces of BoscoVerticale attract scientific and architectural interest in observing the development of an artificial ecosystem. To study and analyze the use of building materials for covering open areas, sidewalks and roads, 6 types of materials were used, determining different levels of environmental friendliness: sand chips, grass, granite, concrete, paving slabs, rubber. Measurements showed that areas covered with artificial materials heat up faster and more than those covered with natural ones. The green spaces of Bosco Verticale effectively reduce the air temperature in summer and create much more comfortable living conditions for people, compared with other areas of Milan [20]. In the biodesign of the complex, plant species were carefully selected in accordance with the climatic conditions of the specified territory of Italy, environmental requirements. The concept of biodesign and phytodesign is also expressed in the visual artistic and aesthetic principle: a combination of forms and colors of plants in accordance with the time, creating a dynamic and picturesque palette of green against the background of gray shades of the building. Green spaces not only enrich the landscape of the city, but also form a space separating from the noise and vanity of the public environment, creating an atmosphere of comfort and privacy.

Rice. 10. Park "The High Line", 2014. New York (USA)

The next embodiment of "green" architecture technologies is the High Line Park (2005-2014), located at a height of ten meters above the city level, where the decommissioned railroad tracks of Manhattan pass. New York (USA) (Fig. 10). The project demonstrates an understanding of the long-term experience of using urban greenways. The High Line Park is a unique green garden in the center of the metropolis, which is a favorite recreation area for city residents and tourists, gardens. Therefore, residents and guests can have fun, relax and admire different views of the city from a bird's eye view. Mini-areas under the cozy crown of trees are installed for recreation. The landscape design of the park successfully thought out living screens of green plantings, closing off unattractive corners of the city for contemplation. In the formation of the landscape design of the park, modern technologies of greening roofs, effective systems of accumulation and outflow of rainwater are used [21]. The aesthetic effect of the High Line solves the problem of creating new public spaces in an area deformed by the consequences of industrialization and functionalist architecture. The implementation of the principles and methods of biodesign in architecture was realized in the construction of the Salk Institute for Biological Studies (1962) in San Diego (California, USA) (Fig. 11). The main goal of the institute, according to its founder, Jonas Salk, was "the creation of a kind of Socratic academy, where the supposedly alienated two cultures of science and humanism would have a favorable atmosphere for mutual fertilization [22]. However, Salk had another dream – "to create an institution

worthy of being visited by Picasso." The talented architect Louis Kahn helped to realize this dream [18]. The design of the institute defined not only the important functional and technical tasks of the institute, but also embodied the architectural image of contemporary art open to experimentation, a new concept of human living space, long six-story buildings forming a wide central interior space. Massive concrete structures on both sides repeat each other, reproducing the principle of strict symmetry and balance. In the center of the architectural complex there is a fountain-source, from which a stream of water flows in a straight narrow strip, connecting with the Pacific Ocean. The fountain-source can evoke various images, associations, allusions, sensations, according to the cultural memory of a person. For example, with the mythological image of "sacred waters", the magical power of spiritual purification and renewal, an endless source of life and knowledge. The composition of the architectural forms of the institute also evokes an association with the sacred space of ancient cultures. For example, an altar – a place intended for performing rituals of sacrifice to ancestors, spirits, gods, heroes. It is curious that altars in the ancient world were not only in the space of temples, they were built in the open space of squares, streets, residential courtyards, near sacred rivers. The architectural image of the institute, located under the dome of the sky and open to the boundless elements of the ocean, creates a feeling of inner balance, peace, creative freedom. The architectural space of the complex harmoniously combines with the natural environment. On the territory of the institute between the eastern and western buildings there is a large eucalyptus grove and a beautiful orange garden. Salk noted that this is "a place of perfection, a creative environment for the creative mind" [23]. The image of a garden in many cultures of the world is a symbol of human virtues, wisdom, spirituality, and moral perfection.

Fig. 11. Salk Institute, 1962. San Diego, California, USA

Examples of successful implementation of architectural projects using the principles and technologies of green architecture and biodesign demonstrate that the bionic approach and interpretation of bionic forms in architecture and design is a promising direction in the process of design, reconstruction and restoration at the global level and can be successfully applied in Ukraine [24]. However, the development and implementation of "green" construction technologies in our country is at an initial stage and is quite slow. There are few implemented projects, and the number of companies actively using a suitable construction direction is also insignificant [24, p. 71]. Now "a conceptual understanding of the post-war restoration and restoration of Ukraine based on the principle of "build back better and ecologically than it was" (Build Back Better) has not been formed, which affects its practical implementation", since there is no single state strategy in the process of planning the renewal and restoration of the country within the framework of the Ukraine Facility plan [26, p.

6]. International partners trying to join this process are forming their own concept of the restoration of Ukraine. However, only a small number of these projects are focused on the implementation of green technologies and principles in construction [27, p. 6]. In 2022, the European Commission approved Communication 31 "Assistance to Ukraine and Reconstruction", which identifies four main components of recovery: the recovery of the Ukrainian economy and society through sustainable and inclusive economic competitiveness, sustainable trade and private sector development, with a contribution to the green and digital transition of the country" [28, p. 29]. A significant role of public organizations of Ukraine is activating the attention of national, regional and local authorities to the environmental and climate components in the country's "green recovery" strategy. A step forward for the development of green construction prospects in Ukraine was the signing in 2022 of a memorandum on the development of the DREAM ecosystem within the framework of cooperation between RISE (a coalition of Ukrainian and international organizations Ukraine) and the Ministry of Infrastructure of Ukraine [29]. In the following period, Ukraine managed to implement several successful projects for the “green” transition, including the development of renewable energy, environmental protection, and waste recycling [30, p.141].

**Conclusions.** Thus, based on the stated objectives of the proposed study, we can make a general conclusion that modern architectural activity has to combine scientific, technical, socioeconomic, environmental achievements and art in a single space for a person. Understanding the essence of modern architecture as a multifaceted socio-economic and cultural phenomenon should form the basis of professional training of future architects and designers, and become a basic requirement for assessing the results of their practical and creative activities. The reviews of scientific papers, publications and studies devoted to bionics in the context of architecture and design, in order to substantiate the prospects of this direction, showed that, despite the wide range of problems of scientific research, the topic of the "Bionic direction in architecture and environmental design." remains relevant and requires further careful study. The introduction of biodesign principles into "green" architecture in each specific case depends on many conditions, factors and is associated with the problems of the development of a technogenic society.

The analysis revealed the modernity of the principles of the bionic direction and the prospects for use in architectural design, and also identified problems and challenges that can be solved using the bionic approach and individuality. Therefore, the strategy of architects and designers in the formation of the living environment should take into account not only financial income, economic factors, artistic and aesthetic principles, but also projections of negative impact on the environment, in particular, nature.

Examples of practical application contain samples of unique projects and the results of their successful implementation, where bionic principles were used in architecture and environmental design, and their effectiveness and advantages are outstanding and impressive. Specialists in the field of architecture and design play a decisive role in the integration of biological systems and principles into construction concepts, creating sustainable, environmentally friendly and harmonious architectural objects and spaces. By optimizing the use of green spaces, cleaning, humidifying and enriching the air with oxygen thanks to modern efficient biotechnologies, architects can reduce energy costs and create a comfortable environment for people to live and work. The potential and prospects of the bionic direction in architecture and environmental design, taking into account the requirements of modern times, including sustainability, energy efficiency, comfort and aesthetics of the objects being created, are assessed as some of the best and deserve further development. The introduction of the principles of "green" architecture and biodesign is one of the ways to overcome the environmental crisis. Active integration of the principles of energy saving and environmental purity in architectural practice allows creating not only functionally efficient and artistically aesthetic spaces for human life, but also environmentally friendly ones. Thanks to innovative construction methods, energy-efficient technologies, and a thoughtful choice of materials, "green" architecture has a positive impact not only on the development of the architectural environment in accordance with

the needs of a technogenic society, but also on nature, climate, and culture. The development of the bionic approach in architecture and environmental design can be formulated as promising, since it has positive world experience in the effective implementation of the principles of biodesign and "green" architecture. Thus, the bionic direction has sufficient potential and can be used to restore the living environment of Ukraine in difficult modern conditions to achieve significant results in the creation of new comfortable, harmonious and aesthetic objects of the architectural environment in the future.

**Further research prospects** can be identified in the following directions: 1) conducting a more in-depth analysis of current trends in bionic architecture and environmental design in order to identify the main development directions and potential areas of application; 2) researching application methods, developing more detailed methods and techniques for applying bionic principles in architectural design and construction to create sustainable, innovative and aesthetically appealing objects; 3) conducting experimental studies using advanced technologies and materials to test new bionic concepts and their effectiveness in real conditions, where possible; 4) exploring the possibilities of integrating bionic architecture and biodesign with other disciplines such as information technology, materials science and social sciences to create more comprehensive and effective architectural solutions; promoting the development of educational programs and initiatives aimed at disseminating knowledge of bionics and biodesign among design students and architects, professionals and the public; 5) introducing bionic concepts into architectural and design practice in order to accelerate their adoption and dissemination. These perspectives can help further develop and understand the role of the bionic approach in architecture and environmental design, and contribute to the creation of more sustainable, innovative and harmonious objects and spaces.

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## ПЕРСПЕКТИВНІСТЬ БІОНІЧНОГО НАПРЯМУ В АРХІТЕКТУРІ ТА ДИЗАЙНІ СЕРЕДОВИЩА

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*Одеська державна академія будівництва та архітектури*

**Анотація.** Стаття присвячена дослідженню тенденцій сучасного розвитку архітектури та дизайну середовища як об’єкту біодизайну та перспективності біонічного підходу. Нові вимоги та завдання, зумовлені технічними та технологічними можливостями, розкривають нові перспективи у формуванні довкілля та професійно-творчої співпраці архітекторів та дизайнерів – «зелену» архітектуру. Визначається важлива роль біодизайну в контексті

техногенного суспільства. Підкреслюється важливість прийняття цілісного підходу у сфері будівництва, що збалансовує екологічні, соціальні, демографічні та економічні аспекти. Розглядаються основні принципи «зеленої архітектури». Визначено, що принципи «зеленої» архітектури активізують впровадження в будівництво не тільки біоматеріалів, але й рекреаційних природних зон та біосистем. На прикладі сучасного досвіду світового будівництва та дизайну аналізуються основні принципи біоніки та концептуальних ідей «зеленої архітектури», що передбачають комплексний підхід до проектування, спрямований на створення функціонального, комфортного, та природоохоронного дизайну архітектурного середовища, забезпечення екологічної чистоти архітектурних об'єктів та простору. Аналізуються методи дизайну та біонічні форми, що впроваджуються в «зелену архітектуру». Проведена оцінка потенціалу та перспектив біонічного спрямування в архітектурному проектуванні з урахуванням взаємодії сучасного суспільства та природи, екологічної безпеки. Доведено, що впровадження принципів «зеленої архітектури» та біодизайну є одним із шляхів подолання екологічної кризи. Виявлено тенденцію покращення якості архітектурних рішень у контексті світової будівельної індустрії завдяки новітнім «зеленим» технологіям і методам біодизайну. На прикладах успішної реалізації проектів «зеленої» архітектури доведено, що біонічний підхід в архітектурі та дизайні є перспективним напрямком і може бути успішно застосований в процесі реконструкції та відбудови України. Визначені перспективи подальших досліджень.

**Ключові слова:** дизайн, біоніка, біонічні форми, біодизайн, зелена архітектура, архітектурне середовище, комплексний підхід в дизайні.