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Journal of Construction Research
https://ojs.bilpublishing.com/index.php/jcr-b

ARTICLE

Concepts and Materialization of Envelope of Architectural Buildings in the Future

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ARTICLE INFO

Article history
Received: 9 November 2021
Accepted: 1 December 2021
Published Online: 17 December 2021

Keywords:
Space
Architecturally defined space
Architectural perspectives

ABSTRACT

This paper is based on a scientific methodology developed by its author (1987) in his doctoral dissertation and later (2004) published in a book. According to this methodology, architecture is understood as a system consisting of four basic elements: Environment, Man, Boundaries and Perspectives. As a case study, this methodology was checked and confirmed (in the dissertation and in the cited book) on the example of an oriental-type town hall in Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and Macedonia, and later in all published books, to date.

In this paper, the author draws attention to the element of Perspective (in architecture) thus emphasizing its exceptional importance in understanding architecture as a whole. In doing so, this element cannot be separated from the other three elements (Environment, Man, Boundaries) since with them he builds architecture as a single whole.

1. Introduction

Perspectives are an immanent dimension of architecture, in all historical periods and in all possible environments (Figure 1). At the same time, the perspectives of architecture in the period of ancient times (for example, Mesopotamia, Egypt or Greece) are different from the perspectives of architecture of the Middle Ages or the perspectives of architecture of the Modern period. The perspectives of architecture seen today, on the threshold of the third decade of the 21st century, are different from the perspectives of architecture in the past, and therefore from the perspectives of architecture that will be seen in the future, in a hundred, five hundred or a thousand years.

However, perspectives in architecture, regardless of the historical period, have their constant as well as a series of more or less variable dimensions appropriate to a specific time and space, i.e. natural and social environment [1,2]. The constant perspective in architecture is related to man, that is, the confirmation of his true values. In doing so, some architectural requirements for human needs are universal and timeless and, as such, are prescribed by standards at the global, regional or national level. It is a “definition area of human comfort” in the field of thermodynamics, acoustics and lighting [3].

2. Environment

The environment is a fundamental feature of Architect-

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DOI: https://doi.org/10.30564/jcr.v3i2.4071

urally Defined Space (ADS). As a complex expression of human battle, architecture is at the same time a strictly defined empirical phenomenon that is always realized in a concrete natural environment in which it should survive as a physical structure, resistant to more or less aggressive natural influences [4]. In doing so, many inputs of the social environment to architecture give the characteristics of a particular society in a historical-temporal context [4].

Natural Environment

When we speak of the natural environment, we mean "those parts of the visible world which were not created by man and which we can discern with the senses" [4]. The term "nature" refers to all physical phenomena, from microscopic to macroscopic dimensions, from matter and energy to the Universe.

As Architecturally Defined Space (architecture) is always realized in a specific natural environment, the mutual dependence of nature on the architectural object as well as the architectural object on nature is implied. This interdependence is sometimes so obvious that architecture (built objects) resembles a living, natural, organism that is in a symbiotic relationship with its natural environment [5]. There are cases when the built environment (architectural object) is imposed on the natural environment by its artificiality to the extent that it more than obviously represents a "foreign body" in a specific natural environment. From the beginning of his existence on Earth, similar to other living organisms in nature, man has made his shelter in the best understanding of the natural environment in question, exclusively from materials found on the spot.

Social Environment

A social environment (society) is a group of individuals involved in more or less permanent social interaction or a large social group that shares the same geographical or social territory, usually subject to the same political authorities and dominant cultural expectations. Societies are characterized by patterns of relationships (social relationships) among individuals who share a characteristic culture and institutions. A particular society can be described as the sum of such relations between its constituent members. In the social sciences, a larger society often shows patterns of stratification or domination in subgroups. Societies construct patterns of behavior by considering certain actions or speech acceptable or unacceptable. These patterns of behavior in a particular society are known as social norms. Societies and their norms are subject to gradual and constant change. As collaborative as it is, a society can enable its members to benefit in ways that would not otherwise be possible on an individual basis. In this way, individual and social (joint) benefits can be distinguished, or in many cases they overlap. Society, too, may consist of like-minded people governed by their own norms and values within a dominant, broader society. This is sometimes called a subculture, a term widely used in criminology. More broadly, especially within structuralist thought, society can be represented by economic, social, industrial, or cultural infrastructure, made up of diverse collections of individuals. In this respect, society can mean the objective relations of people with the material world and other people, and not "other people" outside the individual and the known social environment. Society, in general, deals with the fact that the individual has rather limited resources as an autonomous unit. Cultural relativism as a widespread approach or ethics has largely replaced the terms "primitive", better/worse, or "progress" in relation to cultures (including their material culture / technology and social organization).

Sociologist Peter Ludwig Berger (1929-2017) defines society as "a human product and nothing but a human product, which constantly acts on its producers". According to him, "society was created by humans, but

Figure 1. Left: Architectural Defined Space (ADS), (A. Hadrović, 1987). Right: The incidence of ADS throughout history (A. Hadrović, 2021.).

that creation turns back and creates humans or shapes every day" [6].

Some societies give status to an individual or group of people when that individual or group performs valued or desired actions. This type of recognition is awarded in the form of a name, title, way of dressing or a cash prize. In many societies, the status of adult men or women is subject to rituals or practices of this kind.

Altruistic action in the interest of a larger group is seen in almost all societies. Phenomena of community action, avoidance, perversion, generosity, shared risk, and reward are common to many forms of society. A virtual society is a society based on an Internet identity, which is evolving in the information age.

In some countries (USA, France and Latin America, for example), the term "company" is used in trade to denote a partnership between investors or starting a business. In the UK, partnerships are not called societies, but cooperatives or mutual collaborations often also known as societies, such as friendly societies and building societies.

Each society is defined by several essential characteristics:

(1) Socio-economic relations;

(2) Forms of consciousness (philosophy, religion, science, technique and technology);

(3) Unprescribed forms of behavior and values (morality, tradition ...).

Socio-economic relations represent the relation between the productive forces and the productive relations, which are in a mutually dynamic relationship. The productive forces are people with their knowledge and production experience and their means of work. The importance of productive forces is great because they drive the development of society. In addition, they express the productive capacity of society. Whether a society will live in poverty or material well-being depends on the development of the productive forces. Production relations are relations between people in the process of social production. Production relations have several important levels of meaning:

(1) Property relations;

(2) Relations between direct producers;

(3) Production relations in the management process;

(4) Relations between economic entities and;

(5) Relationships in the distribution of production results.

Property relations significantly affect all other production relations. In one form of production relations private property dominates, while in another form it can be dominated by state, social, cooperative or collective property in some other form.

Relationships between direct producers are a condition and expression of their joint work in the production process. Production relations in the management process occur between direct producers and managers within a particular production unit. Relationships between economic entities occur between different economic entities, i.e. between companies and individuals who opt for a certain type of production. The relations in the distribution of production results are determined by all the mentioned and some other similar relations.

The central question of economic practice and theory is: "For whom to produce and how to distribute what is produced?"

Modern society is characterized by the following features:

- Scientific and technological revolution;
- Connecting humanity as a result of the rapid development of science and technology, primarily electronic-computer;
- Reducing the difference between people, as a direct consequence of connecting humanity;
- Mass culture, created as a consequence of connecting humanity;
- Kitsch (anti-value, "artistic garbage"). According to Abraham Moles (1920-1992), there are five principles for identifying and classifying kitsch: the principle of inadequacy, the principle of cumulation, the principle of synesthesia, the principle of mediocrity, the principle of comfort [7];
- Ecological problems of modern society occur due to the rapid development of industry without control of environmental pollution.

Forms of consciousness (philosophy, religion, moral science, technique and technology) are essential features of any society that have a strong impact on the primary feature of society - socio-economic relations.

Unprescribed forms of behavior and values (morality, tradition ...) are essential features of any society, although they are not prescribed. They are inherited (and changed) from generation to generation and thus confirm their strength.

3. Man

In addition to those needs that have been, are and will be man's constant (food, housing, clothing, reproduction), there will be an increasing number of new needs, while other needs will disappear [8,9]. Some of them will require the construction of a new spatial structure, for some the existing ones will be sufficient (with adequate new equipment), some spatial structures will be demolished.

Today's degree of application of robots in production halls, offices, households, and even in agriculture, suggests robotization to the extent that man will be left with only an inventive-creative dimension in all types of work [10]. Man will be more and more turned to the inner space, and he will stay outside only when he wants to recreate and have fun. New generations will be born and spend most of their lives in an artificial environment. People will get used to the artificial environment in the same way as their ancestors got used to the natural environment. Staying in a living natural environment will be at the level of the exotic. Such a future man will be destined to live in an artificially created environment deep under water, in space, on other celestial bodies, as many authors of science fiction films present to us. The means of visual, audio, and purely physical communication will be effective to such an extent that the physical distance will become completely relative.

Today's stage of development of genetics is encouraging on the one hand, and worrying on the other; today, people are conceived in a test tube, and surgical procedures are performed on the fetus (at all ages). Geneticists predict the birth of an "artificial" man with pre-programmed traits in the future. Such a certain possibility is condemned today by moralists, many sociologists, and ordinary people, but there is no doubt that the day is not far when a "programmed", "artificially created" man will walk through this world; he will carry a coded robot-like identity instead of a common name and surname.

Relationships between people will be based on completely new foundations. Will these relationships be able to be programmed, or will some inner natural force in man reject artificially natural formulas and put things back on a purely natural track? Will "natural" man come into conflict with "artificial" man? Will each of them have their own company? Will a "natural" man be able to have offspring with an "artificial" man? Will all these possibilities represent real progress or the beginning of a collapse into total ruin?

Today's modern wars, in which the powerful from a great distance kill the weaker with efficient and very destructive weapons and follow it all on the screen as if it were a movie, raise the question: what are the real human perspectives?

Today's world can be destroyed by the already existing stockpile of weapons, and tomorrow the Earth as a planet. Will planet Earth be destroyed after all its values have been exhausted and will a new form of life begin elsewhere? Obviously, all possibilities are open.

4. Perspectives of the Boundaries of Architecturally Defining Space (ADS)

Perspectives of the boundaries of the Architecturally Defined Space (ADS) can be followed in three basic directions:

(1) Adaptation to the natural and social environment;

(2) Architecture responses to new 21st century agendas as well;

(3) Autonomization of interior space according to the natural environment.

Adaptation to the natural and social environment

This approach to the materialization of borders (and the development of the CSA as a whole) is, in fact, the first principle of construction to which man has been instructed. This is how the so-called autochthonous architectural traditions came into being. Even in the era of today's high technology, this approach does not lose its relevance.

The responses of architecture to the new agendas of the 21st century

The modern age has imposed new agendas on architecture and urbanism that relate to the natural and social environment, as well as agendas imposed by modern man as an individual. Among the inputs of the natural environment, the most important are: climate (climate change), conservation of drinking water supplies, conservation of biological diversity, loss and lack of arable land. Among the inputs of the social environment the most important are: growing urbanization, new needs in urban regions, increasing ethnic diversity, aging population, increased need for social care, changes in public health service, uneven regional distribution of young/old people, ghetto communities, loss of public space, increase in the number of migrants (inside and outside) in some countries, youth unemployment, intergenerational division, change in gender and sexual norms, populism, decline in trust among people, global unrest, withdrawal of state support to the needy, automation, atomization (reduction of family members), reduction in the number of (smaller) settlements (village extinction), increase in hate crimes and attacks on public networks, possible financial collapse, increase in inequality and insecurity, increase in corporate ownership of funds for organization, dissolution of employment and salary contracts, changes in work patterns, the collapse of the traditional/growth of new media, the rise of localism, the need for new skills/

pressure on the education system, greater use of databases/ more demands for privacy, increasing the concentration of multinational corporate power, restrictions on civil liberties, increased regulation of civic life...

Energy efficient architecture

An energy efficient architectural object is one that uses less energy than conventional solutions. Today, five basic categories of energy-efficient architectural structures are recognized on the global scale [11]:

(1) Low energy house;

(2) Passive house;

(3) Zero energy house (is a general term used for buildings whose energy demand is equal to zero and which have zero annual carbon dioxide emissions);

(4) Autonomous house (house without bills);

(5) House with excess energy.

There is no globally accepted definition of a low-energy house. Due to large variations in the standards of individual countries, a low-energy house built according to the standards of one country does not have to be low-energy according to the standards of another country [11].

Perception of architecture in an energy context is the basis on which architecture is understood and created today. Most European countries (within the European Union) recognize the power of a unique approach to a better life, today and in the future, through projections of the functioning of society, economy, attitudes towards resources and the natural environment in general (all regulated by relevant legislation). It is important to emphasize that all new standards that treat the architecture-energy relationship, see architecture as an energy system in a specific natural and social environment, where the definition area is the physiological comfort of man (more or less the same for all parts of the Earth). In other words, there are no world-universal architectural solutions, but world-universal principles (definitions) on which concrete architectural solutions are realized in a concrete natural and social environment.

It is important to emphasize that valid concepts and materialization of architectural space boundaries from the aspect of heat flow control are not always compatible with the best solutions of conceptualization and materialization of boundaries from the aspect of sound flow management. This circumstance makes the process of conceptualization and materialization in architecture even more complex.

To assess the level of energy efficiency achieved by architectural structures (but also other products), many countries have set up assessment systems implemented by public or private certification agencies. Certification agencies have their own distinctive logo, (Figure 2).

A large number of facilities have already been built in the world that are certified with a high rank of energy efficiency①.

Figure 2. Display of symbols (logos) of some energy certification agencies for architectural structures

Environmentally friendly architecture

Environmentally friendly architecture (also known as green building or sustainable construction) refers to both the structure and application of environmentally responsible processes and resources that are efficient throughout the construction life cycle: from planning to design, construction, operation, maintenance, renovation and demolition. This requires the close collaboration of contractors, architects, engineers and clients at all stages of the project. The practice of green building expands and complements the classic design issues - concerns about economy, usefulness, durability and comfort.

Building information modeling (BIM) is a process that involves the generation and management of digital representations of the physical and functional characteristics of a site. Building information models (BIMs) are files (often, but not always, in proprietary formats and containing proprietary data) that can be extracted, exchanged, or

① Among the more famous facilities are:
- E + Green Home in Kyeong Giu, South Korea (2010). (Architects: Jang Yoon Gyoo, Shin Chang Hoon and Kim Youn Soo),
- One Angle Squqre in Manchester (2013). (Architects: 3D Reid and Buro Happold),
- The Edge in Amsterdam (2011-2014). (Architects: PLP Architecture Ltd (London) / OZ Architect),
- Congress Center and Auditorium "Vegas Altas" in Badajoz, Spain (2014). (Architects: Pancorbo + de Villar + Chacón + Martín Robles from Madrid),
- Apple Campus 2 in Cupertino, USA (2013-2017). (Architects: Foster & Partners).

networked to support decisions about a building or other constructed property. Current BIM software is used by individuals, firms, and government agencies to plan, design, build, use, and maintain a variety of physical infrastructures, such as water, waste, electricity, gas, communications services, roads, railways, bridges, ports, and tunnels.

Although new technologies are constantly evolving to complement current practices in creating "greener" structures, the common goal of "green" buildings is to reduce the overall impact of the built environment on human health and the natural environment through:

- Efficient use of energy, water and other resources,

- Protection of human health and improvement of employee productivity,

- Reduction of waste, pollution and environmental devastation.

A similar concept is the "natural building", which is usually located on a smaller scale and usually focuses on the use of natural materials that are locally available. Other related topics include sustainable design and green architecture. Sustainability can be defined as meeting the needs of present generations without compromising the ability of future generations to meet their own needs. Although some green building programs do not address the problem of remodeling existing architectural structures, others do, especially through public schemes for energy-efficient renovation. The principles of green building can easily be applied to subsequent construction works as well as to new constructions.

The green building movement in the U.S. ② it arose from the need and desire for more energy efficient and environmentally friendly construction practices. There are a number of motives for building green buildings, including environmental, economic and social benefits. Modern sustainability initiatives require an integrated and synergistic design of both new constructions and modernizations of existing constructions. Also known as sustainable design, this approach integrates the life cycle of a building with each green practice used by the design to create synergies between different practices.

A 2009 report released by the U.S. General Buildings Service (GSA Public Buildings Service, Office of Applied Science) presented 12 buildings that cost less in their use and have excellent energy performance. In addition, the tenants were generally more satisfied with the building than the typical ones. These are environmentally friendly buildings ③ .

Parametric design of the facade of an architectural object

Parametric design is a process based on algorithmic thinking that allows the expression of parameters and rules that together define, encode, and clarify the relationship between design intent and design response. Parametric design is a paradigm in design where the relationship between elements is used to manipulate and create designs of complex geometries and structures. The term parameter comes from mathematics (parametric equations) and refers to the use of certain parameters or variables that can be edited to manipulate or change the end result of an equation or system. While the term is used today in relation to computer-aided design systems, there are forerunners for these modern systems, such as the works of a number of architects, among whom, first of all, should be mentioned Antoni Gaudí (1852-1926), who used analog models to explore space design.

Parametric model systems can be divided into two main groups:

(1) Propagation-based systems, where they are calculated from known to unknown quantities in a data model.

(2) Limited systems that solve a set of continuous and discrete constraints. Form detection is one of the strategies implemented through propagation-based systems. The idea of finding shapes is to optimize certain design goals against a set of design constraints.

Some examples of parametric design of envelopes of architectural objects are shown in Figure 3.

Kinetic facades

Kinetic facades are defined as facades that have the ability to react and adapt to changes in environmental

② The U.S. The Green Building Council (USGBC), co-founded by Mike Italiano, David Gottfried and Rick Fedrizzi, was founded in 1993 as a private and non-profit organization that promotes sustainability in design, construction and other activities.

③ These are architectural objects:
Metzenbaum Courthouse, Cliveland (Built 1910, renovated 2005), Davenport Courthouse, Devenport (Built 1933, renovated 2005), Coyle Courthouse and Federal Building houses, Fresno (Built 2001), Arraj Courthouse, Denver (Built 2002), Quillen Courthouse, Greeneville (Built 2001), Duncan Federal Building, Knoxville (Built 1986), The facility at Lakewood for the Department of Transportation, Lakewood (Built 2001), Scowcroft Federal Building, Ogden (Built 2001), DHS The Omaha Department of Homeland Security, Omaha (Built 2001), NPS The Curtis National Park Service, Omaha (Built 2004), Santa Ana Federal Building, Santa Ana (Built 1975, renovated in 2005), Jones Federal Building and Courthouse facility, Youngstown (Built 2001).
Source: Assessing green building performance a post occupancy evaluation of 12 gsa buildings.
https://web.archive.org/web/20130722180030/http://www.capitalmarketspartnership.com/UserFiles/Admin%20GSA%20June%202008%20-%20Assessing%20Green%20Building%20Performance.pdf, Accessed: 28.08 .2020.

conditions. From the very beginning of creating architecture, man relied on role models in nature, imitating them more or less successfully. This effort extends all the way to contemporary architecture, with architectural solutions accompanied by knowledge from other fields of science, technology and engineering. In doing so, it can be said with certainty that the efforts of architects for a new architectural expression were the main impetus for other disciplines that accompany architecture. Architects, in fact, are constantly trying to create architecture that will in many of its segments imitate living beings from nature, i.e. in a way of adapting to the natural and social environment. An envelope of an architectural object designed in such a way that it is changeable, in accordance with the influences from the natural environment (climate), is usually called a kinetic facade. Over the past few decades, kinetic facades have emerged as alternative solutions to classically conceived solutions, designed to meet the increasingly diverse and complex requirements related to user comfort, energy consumption and economic efficiency. This concept can be realized in many ways, from the use of innovative components to very complex projects and advanced technology. Strategies that follow the concept of kinetic facades are mainly focused on the functions and performance of kinetic facades in the context of daylight quality and thermal protection. This is achieved by examining the role of kinetic elements on the facades of architectural structures in order to form efficient kinetic configurations in response to changes in the environment. Recognizing, evaluating, and performing kinetic performances on the facades of architectural structures at an early stage of design will help designers understand design problems and strategies in the construction of kinetic facades. Although the current performances of kinetic facades are intended to improve the performance of buildings, the inclusion of daylight and sunlight, there are noticeable efforts to achieve optimal performance after they are installed in place in the physical structure of the architectural object. The design and evaluation of kinetic facades is a complex task as these processes involve interactive kinetic elements within three-dimensional dynamic physical elements or ever-changing components. Like all other new concepts in architectural design, kinetic facades have their own history as it is necessary to know in order to understand their current solutions and predict their development in the future (perspectives).

Some of the most famous examples of kinetic facades are shown in Figure 4 and Figure 5. The first architectural realizations do not have a kinetic facade in its modern understanding, but their idea is visible in them, realized in accordance with the then technical and technological conditions of society.

Digital (media) facades

The streets of cities, especially those in their business zones, were places of intense human encounters and communication (Figure 6). The products were brought to the edge of the street to be as noticeable as possible for passers-by. Although this obvious display of products has been replaced by contemporary shop windows, in some cultures the fundamental feature of their cities has remained to this day. In western civilizations, especially after the Industrial Revolution (late 19th century), the direct display of goods on the street gave way to shop windows and advertisements. Advertisements were getting bigger, and the lighting made them even more visible during the night (such as Times Square in New York). The American city of Las Vegas got its urbanism and the design of individual buildings as a result of "fast life" and the need to get information as quickly as possible, even when one is not looking for it. Digital (media) facades are a consequence of the general trend to interpolate light in them, i.e. to make that light visible through large panels at night.

The first presentation of the digital facade to the world was shown (1982) in the film „Blade Runner" directed by Ridley Scott (starring Harrison Ford, Rutger Hauer...) with artificial people created by genetic engineering (androids) and their place in society, who edit a futuristic city-state. In addition, viewers were able to watch screenings of this film on displays installed on several buildings in New York City[④].

Innovative concepts of envelope of an architectural object based on models of living organisms. "Keep It Warm" is a project designed by Ilaria Mazzoleni and her students (Figure 7). The envelope of the object mimics the physiological adaptation of polar bears developed for the purpose of surviving in the harshest weather conditions on the planet. The units are designed for the Arctic region where temperatures range from 0 °C in summer and -34 °C in winter. The objects are partially buried in the ground and are no different from the polar bear's lair. The units are also oriented to the southwest, so they can provide the most convenient heat gain from solar radiation. Solar energy (heat and light) is collected by an active shell consisting of glass tubes, like bear fur, and can be operated. The energy is conducted through

④ The United States National Film Registry at the Library of Congress (1993) chose this film for preservation because of its "cultural, historical, or aesthetic significance".

Figure 3. Al Bahr Towers, Abu Dhabi (2012, Architects: AHR), (left) and Schueco's Parametric Façade System (2015, Design Team: Schueco UK Ltd), (right)

Source: https://www.protenders.com/projects/al-bahr-towers, Accessed: 03.09.2020.

Source https://www.schueco.com/web2/parametric_en, Accessed: 03.09.2020.

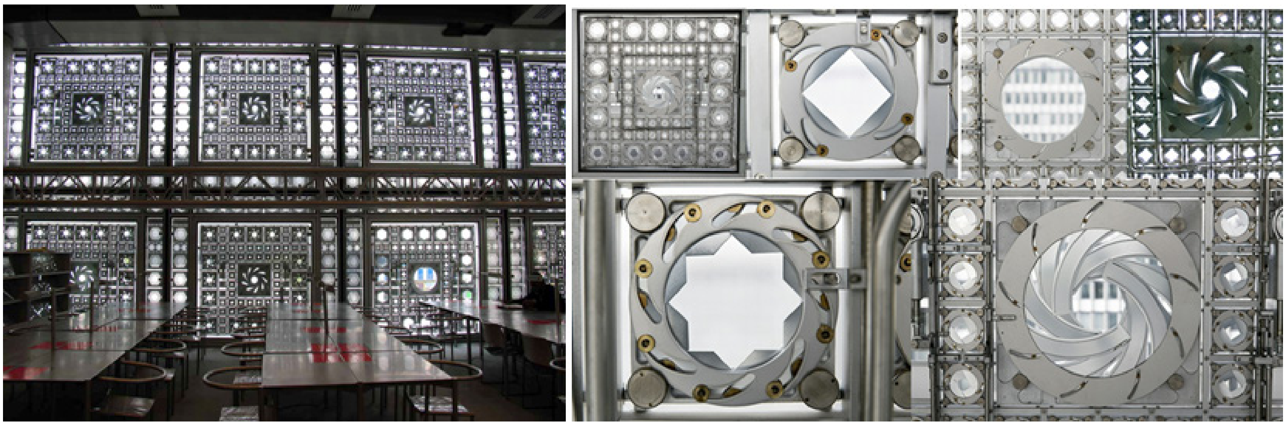

Figure 4. L'Institut du Monde Arabe, Paris, France (1988, Architect: Jean Nouvel)

Source: http://www.leparisien.fr/culture-loisirs/sortir-regionparisienne/une-nuit-de-poesies-a-l-institut-du-monde-arabe-15-11-2018-7943925.php, Accessed: 03.09.2020.

Figure 5. Al Bahr Towers, Abu Dhabi (2012, Architects: AHR), (left) and The King Fahd National Library, Riyadh, Kingdom of Saudi Arabia (2013, Architects: Gerber Architekten), (center and right)

Source: https://www.researchgate.net/figure/Al-Bahr-Towers-Abu-Dhabi-On-the-right-tower-the-screens-are-open-to-let-in-lighton_fig2_318875790, Accessed: 03.09.2020.

Figure 6. Bayer Tower, Leverkusen (2011, Architects: Hentrich, Petschnigg & Partner)

Source: https://www.slideshare.net/ThomasSchielke/media-facadesfrom-monologue-to-interactive-storytelling, Accessed: 03.09.2020.

the tube to the insulating layers where it is stored, stored and slowly released. The system is equipped with phase-changing material, phosphorescent cells, which enable the accumulation of light that is slowly released at night.

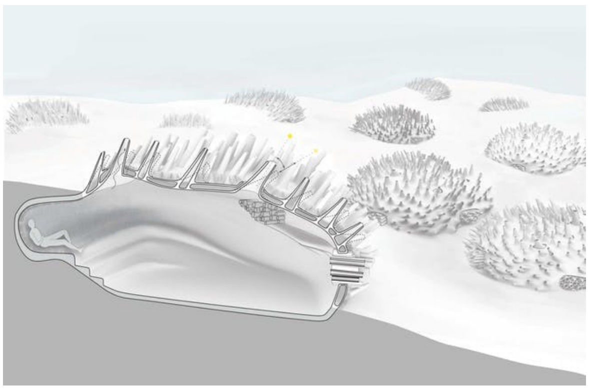

Figure 7. House modeled on polar bear fur (2018, Architect: Ilaria Mazzoleni and her students - Mazzoleni's SCI-Arc studio)

Source: https://archinect.com/news/gallery/95966724/5/architecturefollows-nature-lecture-focuses-on-biomimicry-andcollaborative-Research, Accessed: 12.09.2020.

"The Esplanade Theater" in Singapore is located in the bay and today embodies the cultural heart of the city, an element that projects the creative energy of the performing arts in Singapore (Figure 8). The two rounded shapes provide a dominant legible shape whose design is inspired by the durian fruit, specific to the area. These are light curved frames equipped with triangular glass and a champagne-colored umbrella system that offer an optimized shift between sun shading and a panoramic view from the outside. The result is filtered natural light and a dramatic transformation of shade and texture throughout the day. At night, the building radiates light towards the city, like lanterns by the bay. The Y-shaped physical structure unites the neighboring civic spaces in the heart of Singapore - Padang Greenery, the Old Town Hall and the High Court on the main axis, as well as the development of the Marine Square and the public waterfront promenade surrounding Marina Bay.

Figure 8. "The Esplanade Theater" in Singapore (2002, Architects: DP Architects and Michael Wilford)

Source: https://www.architravel.com/architravel/building/esplanadetheater-complex/, Accessed: 13.09.2020.

Source: https://www.hongkongfp.com/2019/02/10/chinese-hungerworlds-smelliest-fruit-threatens-malaysian-forests/, Accessed: 13.09.2020.

"Smart, Continuous, Active, Layered, Environmentally Friendly, System (S.C.A.L.E.S.)" is a project designed by Ilaria Mazzoleni and her students (Yuan Yuan and Juan San Pedro). The project is the designers' response to their inspirational side-view of the lizard (Uta Stansburiana). The team created a residence in Palm Springs, California where, because of the desert climate, principles were used to mimic the behavior and physiological characteristics of lizard skin. The flexible membrane used in the walls of houses is covered with photovoltaic panels. Similar to the desert lizard, the main design concern is the comfort of the occupants of the houses on hot, dry days and cold nights (Figure 9).

Figure 9. Lizard and S.C.A.L.E.S. project - Smart, continuous, active, layered, environmental, system) (2010, Architect: Ilaria Mazzoleni and her students - Mazzoleni's SCI-Arc studio)

Source: https://www.researchgate.net/publication/307648464_Biomimetic_Envelopes, Accessed: 12.09.2020.

Source: http://www.abitare.it/en/wpcontent/uploads/2010/06/03_Gal700px.jpg, Accessed: 12.09.2020.

Construction in Space

Space missions are usually performed to:

- Discoveries aimed at advances in the world of technology and space,
- National pride and prestige,
- Developing friendly relations between several nations (joint missions),
- Predictions of human survival on other celestial bodies,
- Security benefits and details regarding other nations (satellites).

During sea voyages, travelers and explorers used a variety of methods to preserve food and carry it enough for their survival. The main problem is that they face food conservation during their travels, which used to lead to huge food consumption resulting in a very small amount of food for their survival. Researchers such as Columbus, Cook and Magellan carried foods preserved in brine and syrup with a longer shelf life.

Newer technical-technological procedures have made it possible to preserve food by cooling and canning, which is a major breakthrough in the field of food preservation. In the 1960s, NASA with its advanced technology was successful in sending crews into space. But even after many years of this discovery, it took years to perfect space food. Man in space survives by consuming preserved food (by various techniques) that is packaged in a special way to maintain itself in a zero-gravity environment (Figures 10, 11, 12). On the ship Friendship 7, in 1962, John Glenn (1921-2016) was the first American astronaut to eat food in a spaceship. It was not yet known at the time whether humans could consume and digest food in space. Scientists were not sure how the human body, enzymes and nutrients would react to a zero-gravity atmosphere. Glenn's first consumption was the consumption of apple sauce and a tablet of sugar with xylose and water, which was a historic meal in itself. It has been confirmed that humans can eat, swallow and digest food in the universe. Space food has not evolved in a long time. It took scientists and technologists years to understand the practical problems of food on a spaceship. Food must necessarily provide a balanced diet for astronauts working in space, but at the same time it is important that everything is suitable for storage and preparation in a zero-gravity environment. Therefore, different methods of food processing and packaging have been devised to adapt it to consumption in the space environment.

Figure 10. Astronomers, for now, feed on food produced and brought from Earth

Source: https://qz.com/1277538/the-first-humans-sent-to-mars-willneed-to-3d-print-their-meals/, Accessed: 22.08.2020.

Figure 11. Possible appearance of the future "green house" on Mars

Source: https://qz.com/1277538/the-first-humans-sent-to-mars-willneed-to-3d-print-their-meals/, Accessed: 22.08.2020.

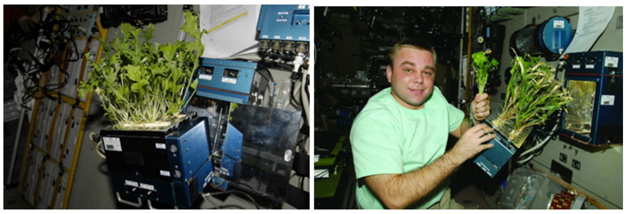

Figure 12. Growing plants (food production) in space. Cosmonaut Maxim Suraev (Expedition 22 Flight Engineer) holds in his hands a plant that is being grown experimentally as part of BIO-5 Rasteniya-2 (Plants-22) in the service module during Expedition 20

Source: https://www.nasa.gov/mission_pages/station/research/news/russian_greenhouse, Accessed: 28.08.2020.

NASA researchers have to solve a lot of problems for astronauts to one day step on Mars (Figure 13). One of the biggest obstacles is where these early pioneers will sleep and live, and after a day of brainstorming, engineers were able to find a solution - the conceptual design of "Ice Home". NASA is working to create inflated ice-covered domes so astronauts can live and work, providing them with protection from extreme temperatures and high-energy radiation. The concept developed by NASA - officially called Mars Ice Home - is an inflatable device, inside the tube, which, when fully inflated, is covered with a thick layer of protective ice. The Mars Ice Home design has several advantages that make it an attractive concept. It is lightweight and can be transported and deployed by simple robotics and then filled with water before the crew arrives. In addition, this concept includes materials from Mars, and since the water in Mars Ice Home can potentially be converted to rocket fuel for a vehicle ascending to Mars, the structure itself doubles as a tank that can be refilled for the next crew.

Use of new smart materials and their assemblies. With the development of new architectural concepts with the support of advanced computer software, the use of new materials (especially nanomaterials) and their smart assemblies will determine the perspectives of architecture. New smart circuits can be fixed or dynamically placed in the envelope of an architectural object, whereby their behavior (performance) according to the influences (especially) of the natural environment will be arranged like the skin of living organisms. The model for creating smart materials and their application in the materialization of envelopes of architectural objects could be chameleon skin (Figures 14, 15). Unlike other animals that change color, chameleons do not change their shades by accumulating or scattering pigment within skin cells. Instead, they rely on structural changes, which affect how light is reflected on their skin. Instead of absorbing light, they use a phenomenon known as structural color, which uses surface nanoscale geometry to allow individual wavelengths of light to bend or reflect in a specific way. The scientists studied the skin of 5 adult male and 4 adult female examples of the chameleon Furcifer pardalis, which inhabits the area of Madagascar and on which they identified two thick layers of cells. The above ones contain nanocrystals of different sizes and shapes, which are crucial for color changes. A chameleon can change the structural arrangement of the upper layer of cells by a relaxed state or excitement, leading to a change. When the skin is in a relaxed state, the nanocrystals in the cells are very close to each other, and the cells reflect short wavelengths, such as, for example, blue. When chameleons are excited, the distance between nanocrystals in the cells increases, which also means longer wavelengths, such as yellow, red or orange. Blue mixed with yellow gives green, which camouflages them perfectly among trees and plants. In the second, deeper, layer of the skin, the crystals play the role of passive thermal protection. This deep layer of skin will not transmit infra-red radiation, but will repel it, and the animal is thus protected from the dangerous solar radiation and high temperatures.

Figure 13. A depiction of a Mars station, where researchers create a community. Utah State University researchers Lance Seefeldt and Bruce Bugbee are part of NASA's CUBES space technology research institute designed to enable food cultivation on Mars

Source: https://phys.org/news/2017-03-food-mars-earth-nasa-usu.html, Accessed: 22.08.2020.

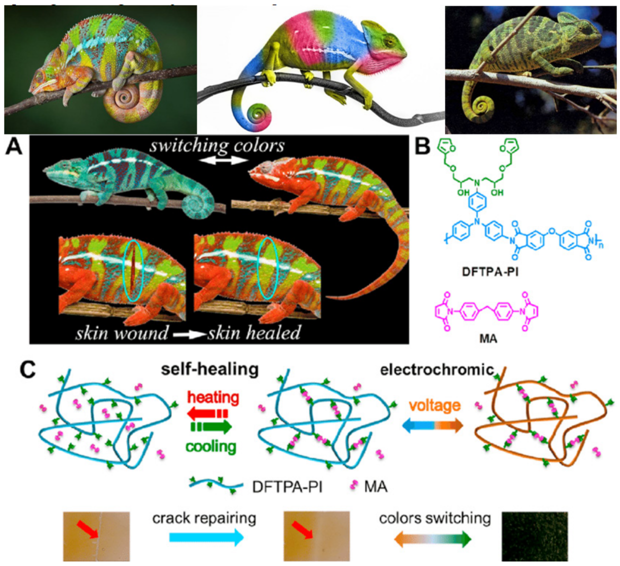

Figure 14. Chameleon

Source: https://privacy.vakmedianet.nl/managementsupport/?ref=https://www.managementsupport.nl/professioneel/nieuws/2019/01/vangrijze-muis-naar-kleurrijke-kameleon-10115917, Accessed: 11.09.2020.

Liquid crystals (LC) have been the subject of research for more than a century. In 1888, Friedrich Richard Reinitzer (1857-1927) was the first to find LC as the cholesterol phase of cholesteryl acetate. Since then, a multitude of LC discoveries have been reported in various LC phases, compounds, and applications. Recent research has focused on applications for displaying or making liquid crystal displays (LCDs). There are still a number of aspects of LC that need to be explored and applied in modern materials, such as solar cells or artificial cell membranes. LC materials can be divided into two categories, thermotropic and lyotropic LC. The first is a pure compound showing LC phases, while the second is a mixture of one or more compounds in a solvent-solvent system and can exhibit LC phases at a certain concentration, both within a certain LC temperature range. LC materials have the ability to self-assemble into different LC phases (Figure 16).

The outer final layer of the envelope of the Vanka Exhibition Pavilion at Expo 2015 in Milan is materialized with 4000 red metallized plates designed by architect Daniel Libeskind with the Italian firm Padana (Figure 17). These slabs, together with the total volume of the Vanka pavilion, are irresistibly associated with the dragon. The panels are decorated with a technological novelty, the possibility of self-cleaning and air purification in their environment. Inside the pavilion, visitors were able to encounter 200 screens mounted on a matrix of bamboo stalks (personification of the forest).

As a model for the conceptualization and materialization of the envelope of an architectural object in the future will be the skin of man and some mammals (Figure 18). The skin is an organ, which as a covering protects the surface of the body and performs various life functions. At certain openings (eyelids, nose, mouth, anus and genitals), it passes into the appropriate mucous membranes. The thickness of the skin is not the same on all parts of the body: it is thickest on the palms, soles and back, and thinnest on the eyelids. The skin consists of the upper part (epidermis), middle (skin) and lower (subcutaneous tissue). The skin contains sweat and sebaceous glands, hair and nails, as well as numerous blood and lymph vessels and nerve endings. Thanks to this composition, the skin performs important functions: it protects the body from various external mechanical, thermal and chemical influences and prevents the penetration of germs from the outside world into the body, regulates body heat, excretion of sweat and sebum, and various harmful ingredients. Through many nerves, the feeling of pain, pressure and heat is transmitted through the skin. There are two to three million sweat glands. They are distributed all over the body, mostly on the palms and soles. These glands have an outlet channel, which ends with an opening in the skin, a pore. Sweat is excreted through the pore. Sweat is a clear liquid, consisting mainly of water (99%) and some organic ingredients dissolved in it. An adult excretes 1 liter of sweat per day. The sebaceous glands, located at the root of the hair, secrete sebum. Their excessive secretion gives oily skin (seborrhea). The whole skin, except on the palms and soles, is covered with hairs, which fall out within a certain period of time and are replaced by new ones. The hair consists of the free part, the stem and the root, which is located in the skin. Hair contains a pigment whose color and quantity depend on their color. With the loss of pigment and the penetration of air, the hair becomes white. The nail consists of the nail plate and the root, from which the nail grows and regenerates over a lifetime. The root of the nail is covered with a thin cuticle.

Thanks to its components, blood vessels, nerves, sweat and sebaceous glands, the skin is connected to the functions of the whole organism. That is why various disorders in the body are often reflected on the skin (redness, blisters, pus, scales, nodules, pigment spots, scabs, lack of skin in the form of deep wounds ...).

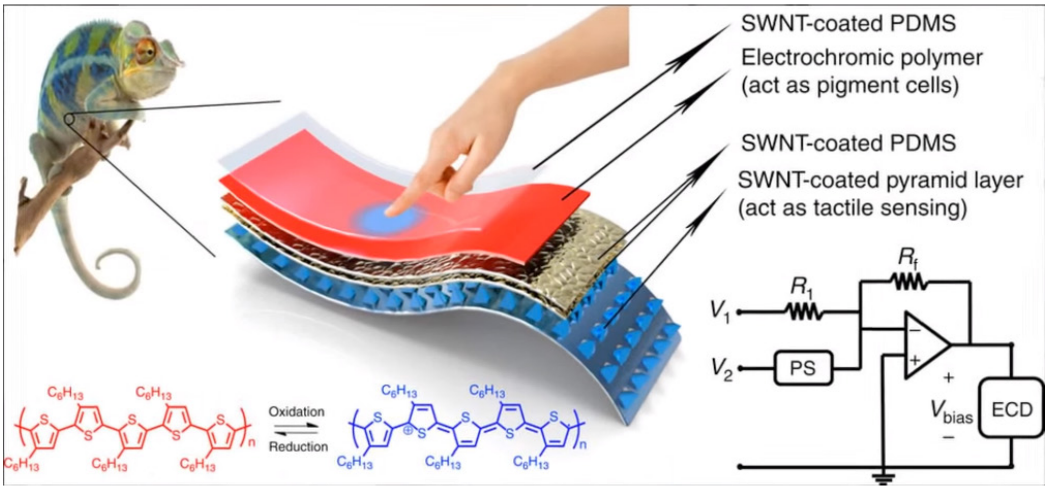

Figure 15. Creation and functioning of a set of artificial materials modeled on chameleon skin

Source: https://www.youtube.com/watch?v=kGkfb7vIPsI, Accessed: 11.09.2020.

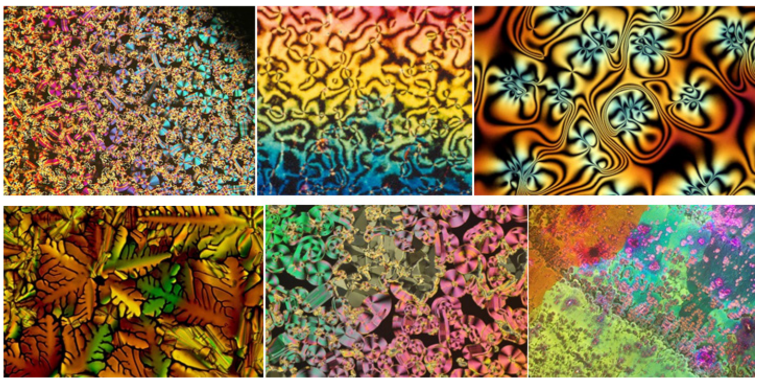

Figure 16. Liquid crystal (LC)

Source: https://www.materialstoday.com/materialschemistry/articles/s1369702114000790/, Accessed: 10.09.2019.

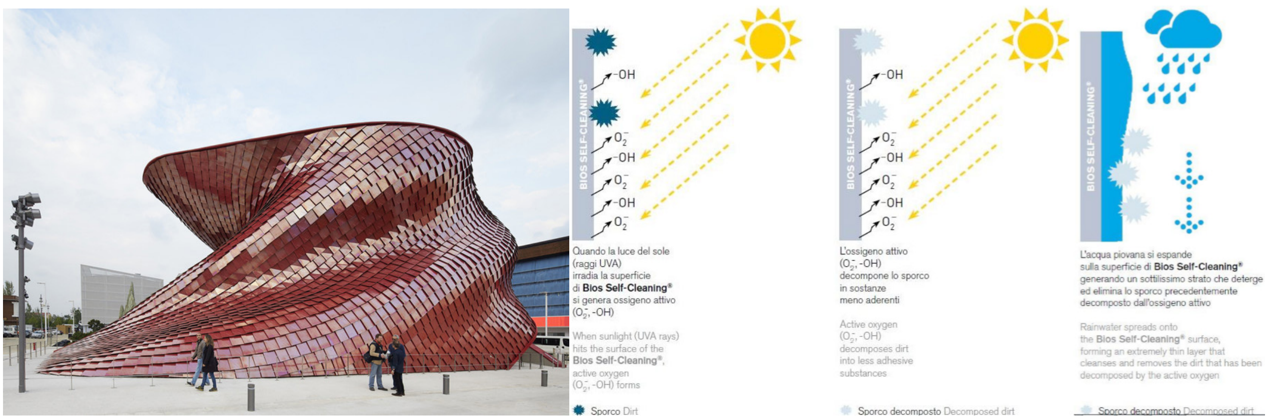

Figure 17. Vanke Exhibition Pavilion at Expo 2015 in Milan (left) and Bios Self-Cleaning façade concept (right)

Source: https://www.archdaily.com/627994/vanke-pavilion-milan-expo-2015-daniel-libeskind/55498bc9e58ece61f2000029-vankepavilion-milan-expo-2015-daniel-libeskind-photo, Accessed: 10.09.2019.

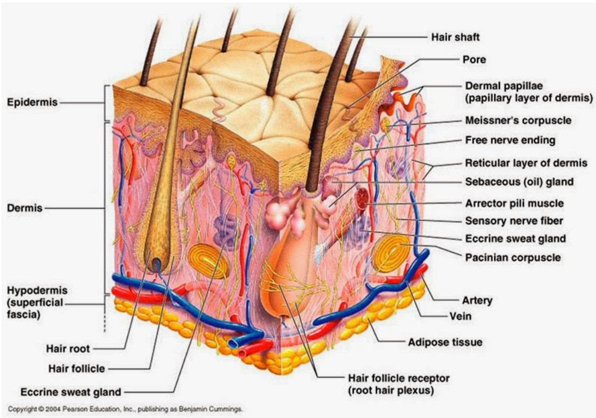

Figure 18. The structure of human skin

Source: https://vasa-enciklopedija.blogspot.com/2014/02/ljudska-kozagraa-i-funkcija-koze.html, Accessed: 10.09.2019.

The fur coats of the polar bear are made of light transparent keratin that does not contain pigments. It has hollow and structured cores with relatively large scattering centers (Figures 19, 20, 21). This gives the fur the advantage of becoming white as a result of scattering a small percentage of visible light of all frequencies without suffering the problem of photodegradation. Animal solar optical technology involves a complementary strategy: fur effectively retains IR radiation from body heat. Interestingly, the capture of thermal radiation does not depend on selective molecular-spectroscopic processes, but is given in a wide range of frequencies due to scattering. This type of scattering is quite independent of light frequency. The light-receiving fur, using an applied optical mechanism, is highly adapted to absorb abundant diffused light in the Arctic region. The increase in thermal energy of this mechanism is moderate and contributes to the general warming of the animal.

The polar bear's light-gathering mechanism should motivate researchers to learn more about this solar energy system and develop technical prototypes - artificial plastic fiber design, with scattering centers similar to those in polar bear fur. The technical challenge is basically focused on adapting artificial prototypes of polar bear fur coat using appropriate radiation of stable plastic material. Fur blankets would cover the facades of buildings, similar to the structure of polar bear fur, serving both as solar energy collectors and thermal insulators (Figure 21).

The leaf tissue of the plant is composed of layers of plant cells (Figure 22). Different types of plant cells form the three main tissues found in leaves. These tissues include a layer of mesophile tissue that is soaked between two layers of the epidermis. Leaf vascular tissue is located within the mesophile layer. The outer layer of the leaf is known as the epidermis. The epidermis secretes a waxy coating called cuticle that helps the plant retain water. The epidermis in the leaves of a plant contains special cells called protective cells that regulate the exchange of gas between the plant and the environment. These cells control the size of the pores (stoma) in the epidermis. Opening and closing the stoma allows plants to emit or retain gases as needed, including water vapor, oxygen, and carbon dioxide. The middle layer of the mesophile leaf consists of the palisade of the mesophilic region and the spongy region of the mesophile. The mesophilic palisade contains columnar cells. Most plant chloroplasts are found in the mesophile palisades. Chloroplasts are organelles that contain chlorophyll, a green pigment that absorbs the energy of sunlight for photosynthesis. The spongy mesophile is located below the mesophile palisade and consists of irregularly shaped cells. The vascular tissue of the leaf is located in the spongy mesophile. Leaf veins consist of vascular tissue. Vascular tissue consists of tube-shaped structures called xylem and phloem that provide water and nutrient pathways through leaves and plants.

The author's concept of an envelope perspective of an Architecturally Defined Space (ADS). On the topic of „architectural perspectives", in accordance with the theory of Architecturally Defined Space (ADS), the author has written in most of his books published so far. In addition to the evolution of new concepts in the history of architecture (Figures 23, 24), the possibilities of developing new architectural concepts have been hinted at, some of which have already been reached.

Here we will talk about possible perspectives for the development of architectural concepts.

Figure 24, e) shows the concept of the envelope of an architectural object (on the achieved solutions, double skin façade, for example) in which another layer is given in the contact ADP-environment. This layer can have different performances: mechanical protection, architectural-aesthetic performance, ensuring the supply of electricity to the building (photovoltage panels).

New constructions (such as tensegrits and pneumatic constructions, for example) enable easy covering of city avenues and squares, thus transforming them into more usable public spaces (for performing various artistic performances, concerts, public gatherings…), whereby the roof membrane, in accordance with its sophisticated performance, can change its transparency, color. (Figure 25)

A possible concept of an ADP envelope is a "house within a house" system (Figure 26). The existing object (or newly designed object) gets a new envelope that can (or does not have to) follow the contours of the object.

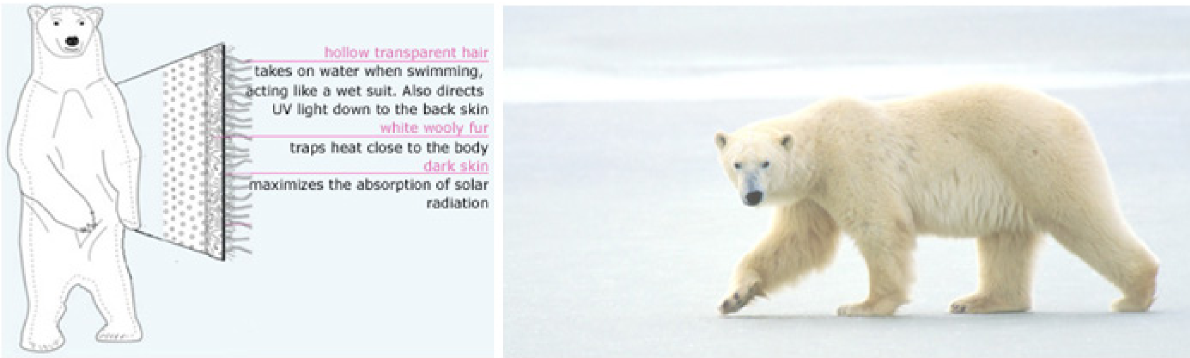

Figure 19. The structure of polar bear fur

Source: https://animaltalk5.wordpress.com/2017/01/07/the-polar-bear/, Accessed: 10.09.2019.

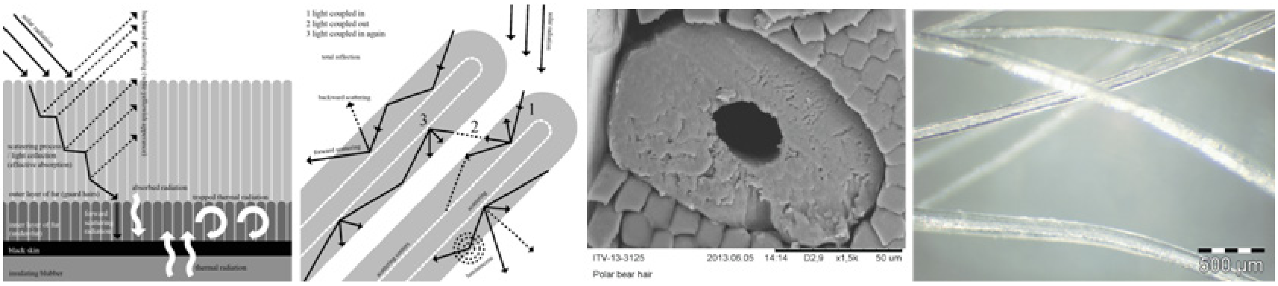

Figure 20. Polar bear skin and fur

Source: https://vasa-enciklopedija.blogspot.com/2014/02/ljudska-kozagraa-i-funkcija-koze.html, Accessed: 10.09.2019.

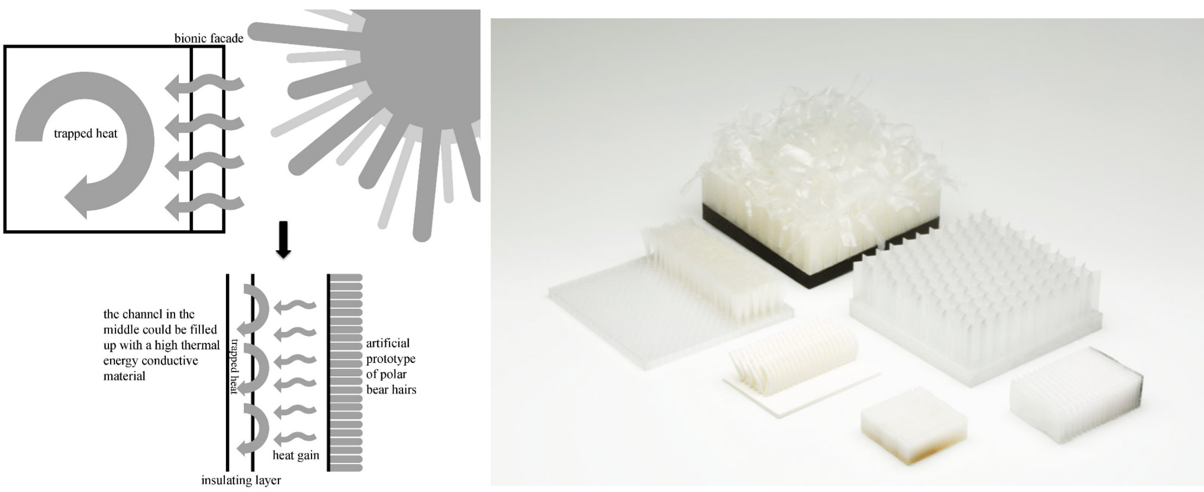

Figure 21. Polar bear fur (left) and polar bear skin-inspired insulation

Source: https://blogionik.org/blog/2016/11/30/ice-warrior-polar-bears/, Accessed: 10.09.2019.

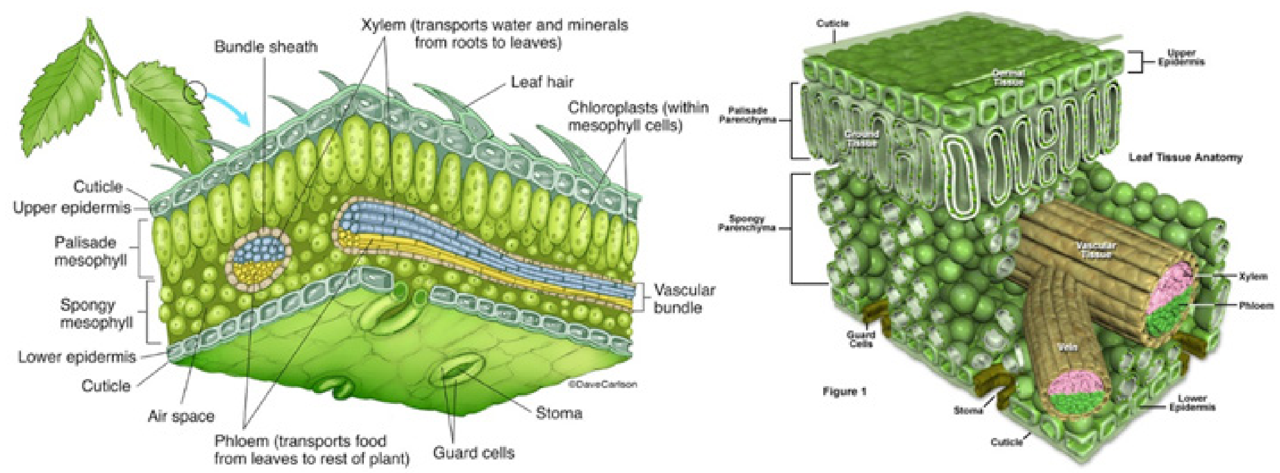

Figure 22. Plant leaf structure

Source: https://www.carlsonstockart.com/photo/leaf-structure-anatomyillustration/, Accessed: 10.09.2019.
Source: https://micro.magnet.fsu.edu/cells/leaftissue/leaftissuelarge.html, Accessed: 10.09.2019.

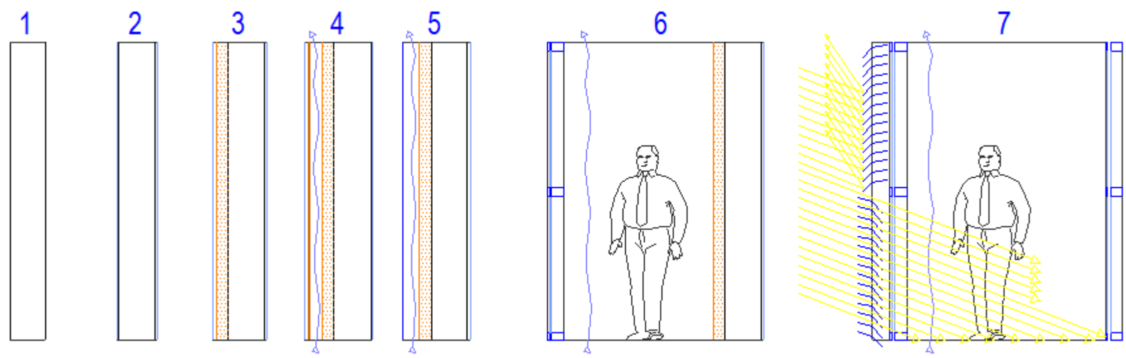

Figure 23. Development of ADS external enclosure concepts (A. Hadrovic, 2015)

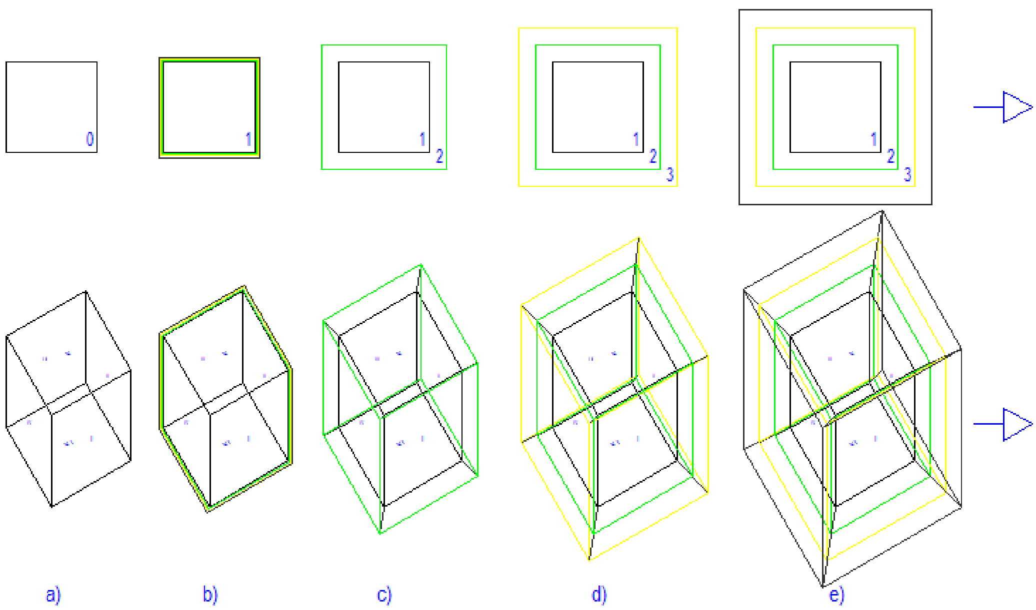

Figure 24. Evolution of ADS garnish concepts, (A. Hadrovic, 2015)

The new envelope can have a wide range of highly sophisticated performance that allows it to selectively manage the flow of energy and matter object-natural environment. The new envelope can be a "solar power plant" for supplying the building with electricity, a "package" that protects the building from various mechanical influences, a "wardrobe" that gives the building a wide range of visual identity.

The author predicts that in the future the envelope (limit) of ADP will be based on the human wardrobe, i.e. it will be selectively variable depending on the season (in latitudes with four seasons), i.e. the overall impact of natural and social threats, according to each specific location of the facility. In this sense, the envelope (border) of ADP will have a "wardrobe" -storage of several layers, each with specific performance (thermal insulation, steam dam, different external final layers that define the architectural and aesthetic performance ...), (Figure 27). Each layer can be selectively "activated", mechanically or automatically, stimulated by the pulses of the corresponding sensors. In this way, the architectural object will function like a "living organism".

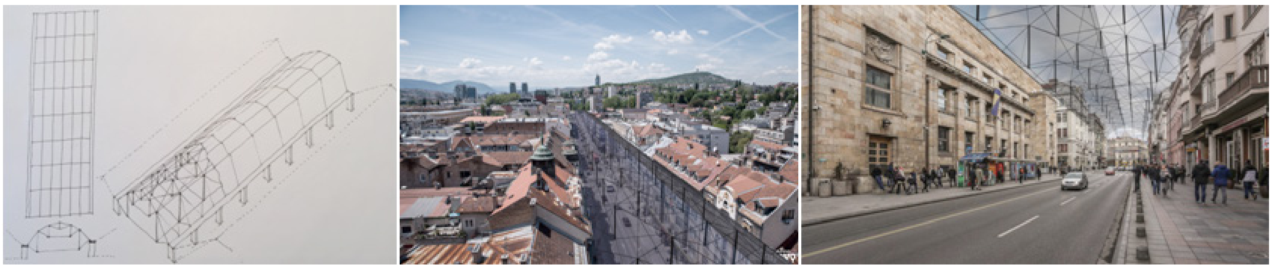

Figure 25. Construction (proposal by Prof. Dr. Ahmet Hadrovic (2019) for covering Titova Street in Sarajevo

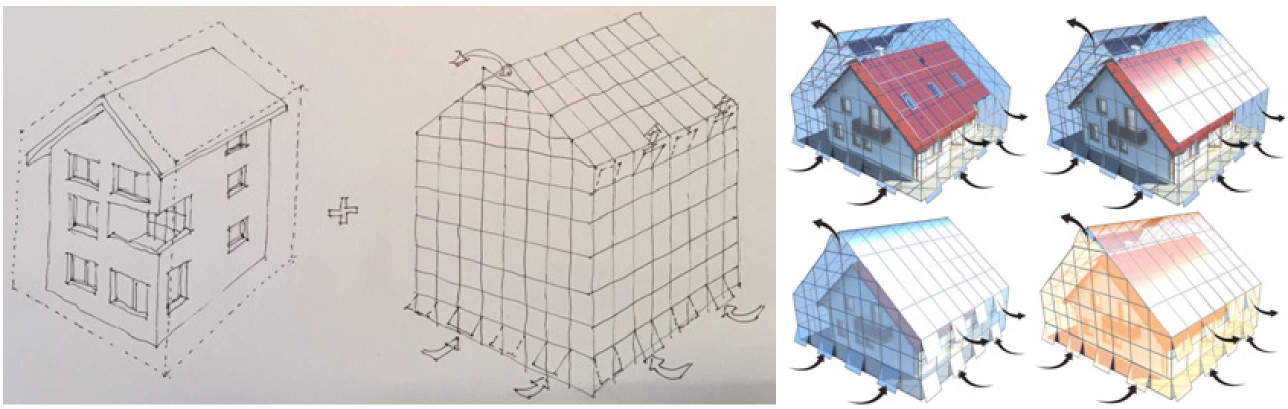

Figure 26. Envelope of an architectural object: the concept of "house in a house" (Ahmet Hadrovic, 2019, Renderings by architect Dzenis Avdic)

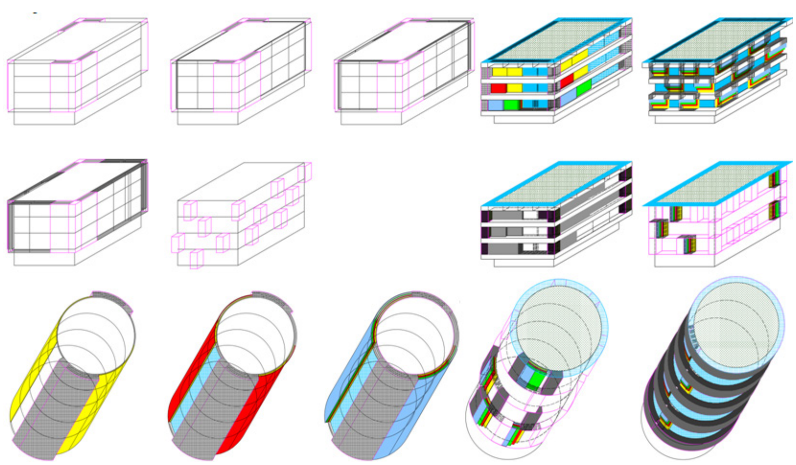

Figure 27. Envelope of an architectural object with "layer wardrobes" (Ahmet Hadrovic, 2019)

5. Conclusions

The aim of this paper is to present the author's theory of Architecturally Defined Space (ADS) which treats architecture as a system consisting of four essential (and always present) components: Environment, Man, Boundaries and Perspectives (Hadrovic, A. (2007), pp. 2-3). All four components are dynamic, changeable, both in terms of the natural environment and the social environment (historical scale). The limits of the ADS are necessarily dynamic. They are created by Man (mostly architects, and once traditional indigenous masters). Perspectives are more or less observable states of architecture in the future that are (whatever they may be) certain. Their view from the perspective of the present, the author sees from the current state of the two elements of architecture (Environment, Man). Namely, the author predicts that the concepts and materialization of the Boundaries of Architecture will threaten the "concepts" of the structure of living organisms, that is, that the appearance (morphology) of architecture will be similar to the appearance of living organisms. The appearance of the ADS envelope will be physically changeable, provided by systems that will function autonomously, with regulated sensors that register all changes in the natural environment, and are set by the requirements of Man (ADS user).

The theory of Architecturally Defined Space (ADS) has the advantage of understanding (interpreting) a specific architectural object (ADS) created at any time in history, and therefore in the future.

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