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REVIEW ARTICLE

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The Biophysical Modelling of the Living Structure

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ABSTRACT

Today, the main development is to explore the relationship between structure and function as deeply as possible. Exact observation, precise conceptualization, the search and exploration of quantitative relations, the efforts made for a quantitative interpretation of phenomena, the development of comprehensive and mathematically formulated theories, the constant interaction of theoretical and experimental research generally serve as models in all areas of scientific research, also in relation to biology. Exact observation, precise conceptualization, the search and exploration of quantitative relations, the efforts made for a quantitative interpretation of phenomena, the development of comprehensive and mathematically formulated theories, the constant interaction of theoretical and experimental research generally serve as models in all areas of scientific research, also in relation to biology. The connection between the three fundamental sciences, physics, psychology and biology, is usually illustrated by intersecting circles arranged in the simplest way in a triangular. In order for a system to become the subject of scientific study, it must be precisely separated from its environment in space and time. Neither can exist without the other. No matter how elusive psychic events are, the organic substrate for this is provided by our individual biological structure.

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Introduction

Life is not the result of the properties of special atoms, but is inherent in the high degree of organization of atoms that otherwise occur in nature according to the general laws of nature. At a certain level of organization in living systems, a qualitatively superior organization is created, which is reflected in spiritual life. Biology begins with the observation and classification of living things, but the study of life phenomena already requires explanation and generalization. The progress was brought by the application of chemistry, biochemistry. The contact areas between physics, psychology and biology, the way they are connected, are worth looking at from all three sides. Issues related to physics arise at all levels of biology: at the atomic and molecular level as well as at the level of cells, tissues, organs, and we can even go further to the level of individuals, populations, all the way to the biosphere. Today, the main development is to explore the relationship between structure and function as deeply as possible. However, the focus is less on the macro, nor on the micro, but on the atomic or molecular level [1].

This endeavor is enforced when we use a variety of modern physical structure analysis methods, or quantum chemical, statistical physical methods, to explore intra- and intermolecular interactions that underlie the fundamentals of life processes, and also when we examine the cybernetic aspects of different life processes, or when we study life processes in terms of chemical substances, energy and charge transport 2].

We can observe that new discoveries in physics almost always drastically change our image of biological processes. Quantum mechanics has been a tremendous development in understanding the forces that hold molecules together and create internetics. The study of living world phenomena also contributed to the development of irreversible thermodynamics. There are plenty of examples of temporal and spatial oscillations in biology. The application of the latest results in statistical physics and irreversible thermodynamics represents a significant advancement in understanding the formation of biological structures as well as the origin of life. If we ask the question of what is needed from physics in biology in general and not in relation to a specific problem, we can say, without exaggeration, that almost everything that does not fall into the world of extremely large sizes and durations [3]. Sometimes there are unexpected application possibilities, and it is these that can bring new results in principle. So a lot may be needed, and it may be the case that certain areas are given preference where appropriate. Physics has developed a great number of measuring and testing procedures and many tools over time to study the different properties of different materials. New methods and new instruments are also used to test biological materials over a short or long period. Again, methods and tools for exploring the material structure can be mentioned as a relevant example.

In addition to the possibilities discussed above, we must definitely address the more general significance of physics

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than the above. This is because the research methods of physics have evolved over time into a scientific approach. Exact observation, precise conceptualization, the search and exploration of quantitative relations, the efforts made for a quantitative interpretation of phenomena, the development of comprehensive and mathematically formulated theories, the constant interaction of theoretical and experimental research generally serve as models in all areas of scientific research, also in relation to biology [4]. Substantial differences in the individual behavior of the biological substrate, however, can only be understood or given a proper, more realistic interpretation if the psychological side of the biological system is taken into account. This is given special emphasis in the case of pathological activities, because the healing of a human system by physical means alone can be completely ineffective without considering the psychological ones.

Medicine ~ applied human biophysics

Practicing medicine did not follow the results of basic biological and medical research with a great delay. This is shown by the recent development in medical imaging techniques; first, the time required for imaging was reduced by a fraction of a second, and then imaging following new principles were introduced (NMR, positron and scintillation camera, thermographic, computer tomography, scanning tunneling microscopy/STM/, PET, scanning atomic force microscopy/AFM). Nowadays, an intensive care unit is unthinkable without data acquisition and process control structures (pacemakers, defibrillators, etc.) built of microelectronic elements. Through holography, the spatial and temporal course of bioelectric activity has also become traceable in three dimensions. This is already one of the applications of laser technology. But laser spectroscopy and laser-based photo-acoustic spectroscopy have also opened a new era in analytics [5].

The use of high-energy lasers in surgery and ophthalmology is now well known. The results of cryobiology have been used for the long-term storage of cells and tissues. In addition, hyperthermia is likely to play a role in the treatment of tumors. In the near future, the modernization of myographic and encephalographic examinations, the diagnostic application of electron microscopic X-ray microanalysis, and the introduction of biophysical examination and separation of cells into diagnostics and therapy are expected. Nowadays, decades of experience in computerized data storage, operation, mathematical statistical control and evaluation of medical and care departments is available. Computer science also allows the creation of non-statistical mathematical models of complex biological processes (drug kinetics, compartment models of the human body, brain and nervous system models) [6]. An example of this is the “artificial pancreas,” a device that models the body’s mechanism for breaking down sugar, constantly measures blood sugar levels, and determines the insulin dosing program that best mimics the function of a healthy pancreas.

A major breakthrough in biophysics and medicine is expected in the near future in the following areas:

- The relationship between structure and function;
- Energy problems of metabolism;
- Understanding the mode of action of different physical and chemical agents;
- Systems theory aspects of life processes;
- Application of chaos theory.

Overall, we can say that the tools of biology and medicine have always been a function of the physics of the era, but it also remained dependent on the psychological state [7]. However, the fact that the laws discovered by physics and the investigative methods set out had an impact on other sciences was a result of the material and technical preparedness of society in a broader sense. Today, the statement that we live in the age of scientific and technical revolution, which is based on the hardly refutable thesis that science has become a productive force, is becoming commonplace. It is an increasing challenge for our economy that the quality demanded by intensive development coincides more and more with the “knowledge content” embodied in products and services. This is natural because, in its inseparable context, the history of humankind must be seen as more than a minor turn in the development of life on our planet and the least imperfect manifestation of this is scientific knowledge.

The most striking technical aspect of the explosive development of the XXth and XXIst century exact sciences was microelectronics. It should be noted at the beginning that both information technology and microelectronics are not new sciences, but technical achievements (innovation phase) that have created a new industrial revolution. The results in this area are explicit: innovations, inventions, but implicitly do not cover and do not exhaust the content of scientific research, because, for example, from the point of view of the organizing physicist, there are less new principles in a microprocessor than in inventing the electron tube or the transistor. In technology, it is not the novelty of the principle that is important, but the efficient organization of the implementation [8]. So biophysics examines the role of physical phenomena and laws in the structure of living matter, in life processes, so that we can then incorporate this knowledge into the general scientific worldview. In the school of thought and methods of biophysics, we encounter the synthesis of physics, psychology and biology and apply the methods of examination of mathematics in its results. Promising endeavors are those that apply the results and methods of modern physics to the properties of the molecules that make up the body and to the simplest biological structures, for the more comprehensive exploration of elementary processes. The current trend in biophysics are thus the efforts made for comprehensive results, which seek to explore molecular and atomic processes in biological objects, as well as spiritual phenomena through the structure of the nervous system.

The connection between the three fundamental sciences, physics, psychology and biology, is usually illustrated by intersecting circles arranged in the simplest way in a triangular. The circles symbolize the sciences, their overlapping areas symbolize the interdisciplinary fields. The common area of all three circles represents a field of science that is related to all three basic sciences and uses the tools of mathematics as an objective method. This includes all that we have referred to above, the character of which is general, comprehensive and at the same time attests to the unity of nature. Finally, no basic science can be considered a closed science, but an interdisciplinary field such as biophysics cannot be considered as one in particular. An essential feature in biophysics is the tendency to bring together hitherto highly differentiated disciplines and merge this part of natural science into a single, unified discipline.

The system

The environment K of the system R is what is outside the system. Everything that does not belong to the given system is called environment. This is also not easy to define. This is why the scientist must have considerations of the system environment that are richer and more complex than the mere study of boundaries P (edge). Very often, the environment is not only beyond the control of the system, but also something that partly determines how the system works.
$P = R \cap K$

The system and environment are not disjointed. What they have in common is the edge of the system, the finite-sized closed surface that separates the system from the environment. Through the edge, there is an interaction between the system and the environment. The edge is part of both the system and its environment. Its position determines the static location of the system, its geometric location within the environment [9]. At the same time, however, as a medium that can be characterized by a factor of conductivity, it determines the dynamic relationship between the system and the environment, as well as the interactions between them.

In order for a system to become the subject of scientific study, it must be precisely separated from its environment in space and time. This is only possible if, on the one hand, we are able to highlight the system in accordance with the established interconnection rules, and if, on the other hand, we are able to delineate the relationships and interactions between the system and its environment [10]. In this case, the subsystems appear inside the system on each other or on the system, or the coercive effect of the system on one or the other, which is also influenced by the edge conditions, through their so-called coefficients of conductivity (V_{jk}).

The numerical value of the coefficient of conductivity gives the current of the extensive quantity (w) for a unit time difference of an intensive quantity (z). If the edge is divided into S_k units of homogeneous surface:
$P = \sum S_k$

Then the total flow of the extensive quantity $\mathbf{w}_j$ over the surface of the whole edge S:

$$w_j = \int_S S_k \sum_{r=1}^{n} v_{jr}\ grad\ z_r$$

This seemingly complicated formula becomes easier to understand when we think of the cells that make up living organisms. Conductivity indicates that the cell membrane is permeable to a particular substance. The permeability of a surface also varies with time per unit. If impermeable to a given material, then the row vector of the conductivity matrix consists of zeros. If we apply it to the vectors of the conductivity matrix column, it means the effect a generalized force F has on the corresponding flux ϕ.

Systems can also be characterized by their function:
– keeping the system characteristic G_i^* at the prescribed value;
– keeping the output at the specified value /$o^*(t)$/;
- safe input-output /i(t) → o(t)/ conversion.
These three functions may change over time.

Table 1: A possible classification of systems

Aspect	Version
Task	Best-first search Regulation
Functioning mode	Discontinuous Continuous
Behavior over time	Constant Varying
Property of signs	Deterministic Stochastic
Character	Linear Non-linear
Internal structure	Constant Adaptive Learning Self-guided

The four essential features of living systems are, in short, the set of content components, structural construction, communication, and intermittent parameters that implement the functions (Table 1.) If we provide a definition of transport phenomena in living organisms and its mathematical description, it would result in the elaboration of the interaction between the system and its environment for the relevant specific case. By transport phenomena we mean the change in "generalized forces" in time and space when they create fluxes to which the conservation laws apply.

According to the degree of integrity, systems are usually divided into two major groups: integral and summative systems. Integral are systems the subsystems of which are not equivalent and in which the removal of some subsystems may result in the disintegration of the system. In integrative systems (such systems are living systems) there is a degree of generalized regulation that results from integrity itself. The feedback principle known from cybernetics does not apply to this regulation. Summative systems are systems of equivalent elements in which the removal of individual elements does not significantly change the properties of the system [11]. In connection to this division, we must emphasize its relative nature.

The summative system, due to the external nature of the relationships, does not have its own constancy that is relatively independent of the state of the constituent elements; the ability to repair potentially damaged interactions is lacking. These systems can be represented by the following type of connection, according to Klaus:

R (x, y) → R' (x', y')   y' = 2.y   x' = 1.x

Integrated systems are established based on internal, mutually compatible connections. In a generalized form, the integral system can be represented in the form of the following structurally different relationship from the previous one:

x' = 2.x – y
R (x, y) → R' (x', y')
y' = 3.x – 2.y

This relationship represents the correlative dependence of the two component variables (x and y) within the global system R: x' varies not only according to x but also y, just as y' varies not according to y but also x. More specifically, in an integral system, a change in the state of one subsystem also affects the state of the other subsystems, and vice versa. This is of great importance in the implementation of regulations within the system.

The Biopsychological System

One of the characteristic features of human thinking is that it considers the world's familiar phenomena as natural, given. My goal here is to present the formation of this "view of life" in relation to the dynamics of its development, and to shed some light on its unique qualities. Today this is made possible by the interdisciplinary research, that in spite of their merely fifthty years of history gave a definitive momentum for life sciences [12]. The more the scientific methods within research of a certain topic, the more thorough the information given by these.

"Mens sana in corporis sano" – that is ***"a healthy mind in a healthy body"*** – refers to the inseparable unity of the biological and the psychic. Neither can exist without the other. No matter how elusive psychic events are, the organic substrate for this is provided by our individual biological structure. The unit is thus made up of two parts, operating separately, but mutually determining each other's functionality. An equilibrium system develops in which when a function is disrupted it burdens the functioning of the organs associated with it which creates a dysfunction in the organ itself as well as in the body and they react to each other. For example, in the case of anorexia or bulimia, both of which have psychological causes and are somatic, the nerve center responsible for disrupted hunger and satiety generates organic damage.

In this, from a biophysical point of view, there are psychosomatic and somatopsychic, i.e. psychiatric disorders caused by organic dysfunction (the latter, for example, kidney diseases, brain tumors, gastric ulcers, etc. are accompanied by psychological changes) are formed. Emotional stress results in anxiety with vegetative accompanying phenomena (sweating, temperature changes, flushing-paleness, nausea, diarrhea, urinary urgency, etc.) [13]. If these vegetative phenomena are repeated, they can also result in organ damage. This is called psychosomatic specificity. Psychic emotion can also affect the effects of certain hormones, not just the functioning of certain organs. A significant proportion of psychosomatic disorders are reactions that persist in the normal state, and only become prolonged and increase in intensity. Repeated stimulus responses result in a qualitative jump from quantity after a period of time, which can lead to a greater or lesser degree of temporal or irreversible changes. A state of an endless cycle is created in the closed system, which thus requires external intervention because the balancing role of homeostasis is disrupted. Based on all this, different groupings can be established: primary and secondary triggers or causes, a symptom of a neurotic or organic process that occurs or develops because of an endogenous or exogenous effect, the internal pathomechanism of which must be interfered with.

The highest level of expression of the operational polyvalence of the human psyche is considered to be creative activity. The distance between reality and model, aspiration and opportunity is an indicator that determines a person's actual level of self-realization. Since these indicators define the whole of psychic organization, they can be used to assess the general level of development of a personality [14]. The level of organization, which expresses the correspondence of behavior to the nature and meaning of external influences, can be estimated by constructing a phase profile of the psychic system based on the main psychic indicators.

This can be expressed in the form of the following relation:

$$S = \frac{\sum_{j=1}^{m} Y_j(t_k)}{\sum_{i=1}^{n} X_i(t_k)} \quad ; \quad k = 1,2,\ldots, p$$

where $\sum_{j=1}^{m} Y_j(t_k)$ is the sum of the mean of the adaptive responses and $\sum_{i=1}^{n} X_i(t_k)$ is the sum of the external effects and stresses, t_k *(k = 1,2, ..., p)* expresses the consecutive motions of the examined period. If the value of S is close to zero, then the personality is characterized by a great lack of psychic organization, i.e. psychic disorganization; if the value of S is close to 1, the individual is expected to respond correctly at all times, to show a state of psychological equilibrium, and to have minimal psychological fluctuations.

With the technical advances that have taken place in our environment over the last hundred years, our body's usual biological adaptation has not been able to keep up with evolution, and as a shield against the emotional problems that have arisen, it has hidden behind psychosomatic perturbations. Personality developmental disorders can occur because of both internal (endogenous) and external (exogenous) influences, due to the disharmony of this co-operation, some personal characteristics become disproportionately predominant, others become irrelevant. If an individual's responses come from an external cause, mostly reversible processes appear. The triggering causal factors are correlated in time and intensity, i.e. they occur during abnormally strong and prolonged exposure and are usually in direct proportion to the strength of the effect and the severity of the symptom. As emotional order and cognitive tension decrease, the reaction slowly dissolves.

By examining the life disappears as we are approaching the lifeless components from the total life. That is, life doesn't equal with the sum of its constituents! The better we disconnect these living units the farther we are gradually distancing ourselves from the biology, then arriving to the superb, eternal and universally physical laws of the lifeless material. The living material is a highly organized complex structural system, able to maintain this composite structure through its metabolism. It is proper to ascribe the qualitative differences within the single internetics levels to the organization of the constituents. It is not possible to understand the totality through its particles;

however, the knowledge of the parts would help us to understand the whole.

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