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The Specific Characteristics of the Biophysical System Theory

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Abstract.

Biophysical model can help to see certain phases more clearly and sharply giving way for experimentation. But by all means, the biophysical model is always suitable to correct faults and direct further investigations in the proper way. Another aspect which equally stresses the usefulness of the model on trial: once we keep a solution in hand we get a great number of testing chance through it as well. We can foretell on the basis of the model in what direction a given biological process shall deviate by changing single parameters. There is no sharp limit between compartments and the number of compartments can be increased or diminished by amplification and reduction, respectively. The enlargement and reduction of the compartments depend on the researcher and the compartmentization is confined by Heisenberg's principle. With the living systems, too, even in the case of very much parameters there exists a critical point, for example the upper limit of the body temperature which goes around 43 ^{o}C in the human being. Similarly, there is a critical value for the blood pressure, for the oxygen concentration, etc. These problems belong to the most difficult tasks of the up-to-date science and evenly appear in the most various chapters of the natural sciences. The biogenesis in the univers shows scale behaviour, too: of the cell it is characteristic to be living (it can be cultivated under laboratory conditions), organs built up of cells are living (organ transplantation is possible), organisms built up of organs are also living, according to the most universal law of the biogenesis, life appears on a certain evolutional stage of the universe, in different parts of the space. From the biological point of view the types of interactions are no more so clearly confinable. First of all we can consider the metabolism as a fundamental interaction which realizes the unity of the living organism with its environment. The life under study is disappearing as we proceed from the living whole towards the lifeless constituents. This means that the life does not equal to the sum of its constituents. The more we dissect these living units the farther we get from the biology and finally we reach the superb, eternal and universal physical laws of the lifeless matter.

Keywords: Biophysics; System Theory; Compartmentization; Internetics; Scale Laws; Phase Transformation.

Introduction

The expression „system" has been used for a wide range of phenomena. Thus we speak of numerical systems, planetary systems, communication systems, regulatory systems, biological systems, teaching systems, political systems etc. Part of these are conceptual constructions, the other part comprises physical entities. The system itself is a fundamental conception of which we don't give any definition, instead it will be circumscribed. Temporarily, the following wide and broad circumscription could have been done for the system: any conceptual or physical entity made up of parts depending on each other. According to Bertalanffy [1]: systems are collectives of such interacting elements for which certain system laws can be applied. This characterization would not work as a kind of circulus vitiosus if an independent definition of the system laws were available but there was not.

The system is a fundamental concept which is not defined. The behaviour of the system is consisted of the complexity of processes mutually connected with each other and characterized by function ties. Generally spoken a function link between processes there exists only if each of them is needed to accomplish the desired output and if these all depend on each other. The nature of this mutual dependence can be exactly defined. Both the output and the processes taking part in the function link can be defined by a set of certain characteristics regarded as variables. [2] From the point of view of the output, processes will be regarded mutually consistent if the alteration of any variable describing one of the processes will influence the modification rate of any output-variable and it also depends on every other substantial process variables. If, therefore, all variables are expressed by continuous quantities then any process-variable's derivative of an output variable will be the function of all other process variables.

As to the systems, the Heisenberg's indefiniteness relation [3] is of great significance because if the information expected by the researcher from the system is of the same order of magnitude as the system itself then the information cannot be applied for the system and cannot be even achieved without changing the system. This principle has been verified first in the physics but its significance is ever growing as we proceed through the biology towards the social sciences.

Biophysics is a borderland science

The three-dimensional model goes one step further by taking into account both the forms of motion and the over-lapping levels of existing systems. According to this idea, the real world has a layered structure. It contains five main layers: the inorganic (inorganic systems), the organic, the social, the intellectual and the spiritual. [4]

But interdisciplinary fields can also emerge between several layers, such as biophysics, which connects the first, second, and fifth layers. The biophysics in mentality and technique is a synthesis of physics, psychology, and biology. In reaching a right result, the biophysics is employing the investigation methods of the mathematics. The main goal of the biophysical cognition as that of a borderland science is to reveal and cautiously draw up the laws guiding the motion and development of phenomena. The phenomena investigated by the biophysics are in steady fluctuation, nothing of the sort unambiguous causal relations can be determined because their origin and manifestations are based on non-linear causal connection. In biophysics, the objectivity of a theory will be esteemed according to the followings: the measure of the effect and intervention to the phenomenon under study, the measure of drafting and expressivity; the level of usefulness. Every biophysical experiment bears the personal intuition of the researcher and especially in the interpretation the mark of the individual prejudice (one-sidedness), inventiveness. The reason stated by the biophysicist must mean an advance somewhere to answer of one scientific question otherwise the statement won't disclose any information.

The biophysics is a borderland science (between the first, the second and fifth layers). [5] Biophysics is searching for, dealing of and teaching the forms of the connections between the inanimate nature, the living world and the spiritual life, the applicability limits of their own laws in the other medium, their common mutual interactions. The basic aim of biophysics as a borderland science is to discover conformity to the rules of the greatest philosophical problem that of „being and not being" and in order to reach it the only exact scientific weapon will be employed: the mathematics. Those pseudo-sciences, borderland sciences, interdisciplines dealing with life will turn into exact only while they become axiomatic. [6]

Biophysics undertakes, by means of mathematics, description of the so-called homeostasis established by the dynamic equilibrium of the common normal state of the nature, the living world and that of the spirit, resp.

The Compartmentization

By compartmentization in the biology it is meant that the localization of some components of the metabolism (substrates, enzymes, coenzymes, stimulants and inhibitors) within the cell is identical in order to secure a harmonized co-operation, or on the contrary, if their localization within the cells is different it may make interactions impossible under normal circumstances. Many times it enables a sudden state of reactivity another time even inversely. This principle prevails both in the cell and in the organella and this is why metabolic reactions not always take place in vitro identical to those in vivo. The very same matter (e.g. metabolic product) may occur in different cell organs within the same cell so that its exchange between the different compartments is slow. [6]

The system theory has generalized this biologically interpreted compartmentization for the systems. The components of the systems may be arranged in groups according to spatial, temporal, structural and functional parameters and so you can obtain the compartments of the systems. By dividing the systems into compartments, the modelling of the structure and function of a given system will be promoted. Taking into account certain border conditions compartments enable us to constitute mathematical interrelations. [8] According to this, if the order of information has reached the order of magnitude of the compartment then there's no reason for further compartmentization.

Enlargement and Reduction

It is an empirical fact that the construction of the matter shows certain hierarchic structure. The grades of this hierarchy are generally characterized by well separable distance-, time- and energy-scales. As a matter of fact, this kind of separation enables us to create in se more or less closed theories for the description of movements on certain levels of the hierarchy.

Where is the point to limit the extensibility of rules for larger systems as controlled in the range of the excessive distance? Is there any way to find means whither the frames of experiences and that of the theoretical system to approach regularly and with scholarly character the alteration/modification or constancy of the natural laws during the change of the linear dimensions?

In the case of enlargement and reduction of systems and compertments, respectively, experts' well acquitted method is the similarity- (comparative) and dimensional analysis. [9] The professional terminology has named it renormative transformation. The enlargement of compartments will be carried out technically with the help of microscopes, fieldglasses, telescopes but recently even computers are suitable for such operations. As far as the computer is concerned, enlargement can be conceived in a figurative sense, in the praxis we have the computer calculate far more points of intersection than before and these will be plotted in a larger scale system of co-ordinates lines. [10]

A concrete system or compartment can be examined in its given state using different scale enlargement. Let's double, for example, the enlargement of an image identical to the reality, i.e. the distance of two points to be twofold. In the meantime let's diminish the resolution e.g. to the half of it, i.e. the real distance within which points can be substituted by a single one should be doubled. By binary transformation we get a new image of the system which may be interconnected with another real state of the system. Of course it is essential by what objective change of quantities nature can bind the two states. [11] With this knowledge the mathematical transformation can be only equalled to the structural reality of the system.

In the course of microscopic examination of the biological systems – irrespective of the kind of microscopic study – we proceed like mentioned above. In the biology not only the enlargement will be used in examining living systems but the diminishing, too. We reproduce and examine recurrences taking place in the biosphere under laboratory dimensions. It was the diminishing to allow breakthrough in our knowledge relating the origin of life by producing the primary atmosphere of the Earth in flask. [12]

In a given system the number of the compartments increases by enlargement and it decreases by diminishing. Both enlargement and diminishing is limited by the technical apparatus, the measurability and domains of the parameter and by the Heisenberg's postulate.

Phase Transformations

Water turns into vapour on 100^oC and 10^5 N/m^2 pressure, whilst its density suddenly changes. There is a point, the so-called critical temperature, above which the alternative physical condition ceases to exist apart from the value of the pressure. On this temperature (647 ^oK) is no more difference between the density of the water and the vapour and above it there is already a homogeneous state. [13] Apart from the disappearance of the density-difference, this transformation point is highly interesting also from the point of view of other physical characteristics, e.g. the specific heat which by approaching the point either from below or from above seems to increase beyond every value. Ferro- magnetic materials, for example, show similar transformation. These loose their magnetizedness above the so-called Curie-point (for the iron nearly 100^4 ^oK). On the basis of the value of magnetizedness we discriminate quantitatively two kinds of behaviour, two phases. If the microscopic magnetic momentary are nearly parallel the magnetizedness differs from zero, if they stay promiscuously then the resultant magnetic momentum equals zero. [14]

Increasing the enlargement of the compartment the crystalline structure of the matter appears. It is curious that on the course of the macroscopically well observable sudden change, there is no abrupt change in the interactions of the single microscopic constituents, e.g. the little magnetic needles. In the compartment under study there are two tendencies fighting against each other. On one hand the interacting magnetic momentum of the iron atoms try to stay parallelly which, on the other hand, will be frustrated by the thermal motion on higher temperature and as a result the magnetic needles will point confused. [15]

The size of the compartments (correlation distance) increases more and more by decreasing the temperature towards the critical point. The system becomes critical at the temperature where the size of any incidental fluctuation reaches that of the whole sample, i.e. reaches the characteristic Heisenberg's limit of the system and so the magnetizedness different of zero comes into being. Since the examined macroscopic system is infinitely large as compared to the atomic measures, the endpoint of the above process can be proclaimed by saying that the correlation distance is infinite on the temperature of the secondary phase transformation. By halving the original enlargement, we though fade the molecular image and couplings also change but now the distance of coherency will not diminish because the half of the infinity is also infinite.

Scale Laws

For the middle of the eighties, enough experimental and theoretical information has been collected to attempt the formulation of the new phenomenology of the phase transformations. The scale laws have been recognized, these specific regularities of the critical state which are completely strange for the behaviour found in the thermodynamically steady phase. For, the experimental and theoretical investigations have unambiguously shown that the singular behaviour of the different system-characteristics in the critical domain can be described by simple power-functions. [16] It turned out further that the exponents of these powers, the so-called critical indices are highly independent from the material quality of the system under transformation. To be more exact, these systems can be ranked in such wide classes, in the so-termed universal classes whithin which the value of the critical indices is fully independent from the material quality, notwithstanding that the systems in question show no common feature in respect to the acting dominant internetics, to the characteristic energies, to the hierarchic level, etc.

In together there are two factors the critical indices depend from: one of these is the dimensionality of the system under study, the other determining factor is the symmetry becoming settled during the phase transformation. Thus by these very general factors will the limits of the universal classes be defined. For such degree of universality and independency from the material quality we hardly find examples in the natural sciences.

It has been also turned out from the critical indices that they do not depend of each other but satisfy certain simple interrelations. [17] These have been called scale laws. The scale laws are even more universal than the indices themselves, their validity covers all universality classes. The examinations of theoretical systems have discovered that it is the coherence distance and its limitless growth to hide in the background of both the scale laws and the universality. The behaviour of a system in the critical state is decisively determined by fluctuations of the size of coherence length and on this half- macroscopic scale the atomic details become insignificant. The scale laws as recognized in the problematics of the phase transitions have meant the key which opened the gates for the expansion of the field. [18]

It is worth perhaps to mention that the situation in which the divergency of a parameter leads to scale-behaviour is not fully unknown in the natural sciences. Thermodynamics in its whole shows also scale-behaviour: in a system of N particles the intensive parameters are proportional to No, its extensive parameters to N, the relative scatterings to $N_{1/2}$. Here the parameter tending towards infinity is the number of the particles and the theory as a result is the most universal among all physical theories: it is valid for every system of high grade of freedom interacting with shortrange forces.

Internetics

There is a steady interaction between the material objects on the most different levels and in the most various forms. The interaction is a general concept which – like the system – shall not be defined. We try perhaps to explain, to circumscribe it which still, of course, is not a definition. Interactions are the concrete outward forms of the matter's existing mode. We know only the finite extension – in time and space alike – of the material universe and so we posses only limited knowledge concerning the possible outward forms and modes of the matter. But the types of the interactions will further increase, for sure, as a function of the scientific research and the knowledge of materials. The internetics deals with the analysis of interactions, with the description of their characteristics. [19]

The most different objects of the material world affect mutually each other. To our recent knowledge in physics and chemistry, the interactions of different type are attributable to four fundamental forms: gravitational, electromagnetic, weak and strong interactions (nuclear forces).

These interactions determine the movement of the matter on different levels: the weak interactions and the nuclear forces are the movers of the subatomic phenomena, in our surrounding mezoworld those are the electric forces to predominate, while the motion of the large mass celestial bodies is determined by the gravitational forces. On the level of atoms, molecules and bodies built up of these the electric interactions prevail. The four kind of interaction do not exclude one another their effect can get along together, simultaneously. In the stars, for example, the gravity can condense the matter till nuclear forces in the end start to be operative. The manifestation of the individual interactive types may be very diversified depending on the material systems. For example, interactions between ions, dipole moments, various types of chemical bonds, the very weak dispersion forces between molecules and atoms not possessing of dipoles etc. can be traced back to the electric character. The peculiar manifestation of the interaction of moving electric charge is the magnetic space.

It is also given the interaction of the individuals within the species, the interaction of the species between each other and we can also speak about the interaction of the biosphere and the lifeless environment. There are interactions on other levels as well, like those between the matter and the consciousness, the human life and spiritual manifestations, etc.

The major characteristics of the fundamental interactions are as follows: the time, the intensity, the range and the symmetry of interaction. [20]

Generally spoken, with the characterization of the single interactions it is very important what kind of so-called symmetry they show, what symmetries hold true of them, i.e. what laws of conservation will predominate during the given interaction. In other words, one type of interaction exhibits symmetry against a certain character while nothing against the other. So the strong interaction shows symmetry against the rarity whilst the weak one not. Similarly, mating shows symmetry against the entity of the life but the death of the individual due to an infectious disease not.

Symmetries deserve particular attention. Some of them are valid for more types of interactions, others for less or eventually characteristic for only one. The laws of conservation valid for more interactions are as follows: that of energy, electric charge, the entity of life, the barion-charge, the impulse momentum, the lepton-charge, the rarity etc. The law of the information-conservation is in a special position which is known just as a presentiment but failed to be bound in the frame of quantitative correlations with the entities of energy, impulse, mass, life consciousness.

Effort has been made with the internetics to investigate not only the single types of the interactions on a least wider scale, but also the dynamics of the effect of the different interactions on one another. We try to apply this attitude consistently in questions relating to the biophysics of the life. We are trying to explore the life-bound phenomena as a function of the mutual effect of the biological and the physical-chemical interactions. [21]

The living matter is such highly organized material system disponing a complex structure which is able to sustain this structure only by continuous workload – through the metabolism – performs work against the increment of the entropy. It is the right way if the qualitative difference between the single internetic levels will be reduced to the organization of the constituents. The whole cannot be explained on the basis of the parts, knowledge of the parts only procures the interpretation.

As it is evident from the preceedings, the phase space of the systems capable for chaotic movement rather complicated: at the same time it contains the periodic movements found quite regular and those randomly confused. The situation starts to be very interesting when we enlarge a small detail. The enlargement occurs with computer.

If we enlarge a small compartment to its original seize we learn to get a spatial configuration of the same kind as the whole, i.e. you will find on it the discrete intersections of the periodic movements, of which a newer chain composed of finer links, moreover a diffuse set of points corresponding to the chaotic movement. If we now further enlarge a subcompartment of this enlarged compartment we get again the same kind of picture and so on!

In order to get a comprehensive image of the life, we have to harmonize the singular observations in the future, too, and synthesize the fragments even if we know that these fragments themselves are also delicately composite structures. Life is the attribute of the whole. But the indivisible whole is complicated beyond belief and brings the researcher into a difficult situation and, in the same time, it bids fair prospects to explore all beauties and mysteries of life for those who undertake it.

The Part and the Whole

The life under study is disappearing as we proceed from the living whole towards the lifeless constituents. This means that the life does not equal to the sum of its constituents. The more we dissect these living units the farther we get from the biology and finally we reach the superb, eternal and universal physical laws of the lifeless matter. The living matter is such highly organized material system disponing a complex structure which is able to sustain this structure only by continuous workload – through the metabolism – performs work against the increment of the entropy. It is the right way if the qualitative difference between the single internetic levels will be reduced to the organization of the constituents. The whole cannot be explained on the basis of the parts, knowledge of the parts only procures the interpretation. [22]

As it is evident from the proceedings, the phase space of the systems capable for chaotic movement rather complicated: at the same time it contains /includes the periodic movements found quite regular and those randomly confused. The situation starts to be very interesting when we enlarge a small detail. The enlargement occurs with computer. If we enlarge a small compartment to its original seize we learn to get a spatial configuration of the same kind as the whole, i.e. you will find on it the discrete intersections of the periodic movements, of which a newer chain composed of finer links, moreover a diffuse set of points corresponding to the chaotic movement. [23] If we now further enlarge a subcompartment of this enlarged compartment we get again the same kind of picture and so on! Hence the most peculiar attribute of such system is that however small compartment of them is similarly complicated, complex than the whole system itself. As a consequence, the parts of the system are in no way simpler to the whole of it. By reason of this logical explication you can already understand the statement of the biologists that the cell itself is just as much complicated than the living organism. [24]

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Conclusion: On usefulness it is meant how the biophysical theory can be applied to the biology, i.e. how it helps in the alignment to sum up the results dispersed so far. The lesser observations or experimental results have been left over the estimation stacks deductable from the biophysical axiom systems the more exact the biology becomes to be. [25] In this context our theoretical discernment should be stressed that as long as some important problem and elements will not be cleared on the level of the biology one cannot expect epoch-marking discoveries from the biological point of view. Hence the biologist must not wait idly that the biomathematics, biophysics, antropology, paleontology should solve its essential problems. We have to agree in turn with Joshua Lederberg [26, 27] the Nobel-prize winner geneticist: „Biology is too important to be left just for the biologists."

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