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Original Article

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The Biophysical Modelling of the Systems Theory

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Résumé

Modelling in simplest formulation can be conceived as a sharp polarized inquiry of the respective phenomenon.

A fortunate model describes the given momentary acquirements but beyond this it enables assumptions which can be then translated into the language of the experiment and on this basis you can arrange certain new exprimental conditions and situations. The biologist has to abstract parts of the biological process substantial from the point of view of the model and has to select those essential points the physicist willingly accepts and in which he will be ready to collaborate. Moreover, if members of a model family can be transferred into each other unequivocally enough then we can speak about a theory-forming model system. The biophysical approximation of the life processes leads always to the application of some kind of physical model. The biophysical approximation of the life processes leads always to the application of some kind of physical model. The system is a fundamental concept which is not defined. For practical reasons, let's circumscribe the concept of the system more exactly as such an arrangement of the constituents which serves to reach the concrete purpose according to a certain programme. The hierarchy of the systems will be built up according to a spiral line expanding in breadth and depth towards the infinity.

Key words: system, modelling, hierarchy of the systems

Introduction

Natural phenomena are in general very complicated. We have to select, therefore, the most characteristic parameters of the processes and create such constructions in which the processes can be realized with good approximation. A biological model is called that partial set to be studied which has been selected from the set of our available knowledge, assumptions as well as from the results of the already completed biological experiments and investigations. Hence the starting point of every modelling is some sort of an observable phenomenon. Modelling in simplest formulation can be conceived as a sharp polarized inquiry of the respective phenomenon.

A fortunate model describes the given momentary acquirements but beyond this it enables assumptions which can be then translated into the language of the experiment and on this basis you can arrange certain new exprimental conditions and situations. An adequately selected model will promote not only raising the question but also the scientific investigation of the phenomena. Natural science cannot be devoid of the model but it should meet the actual reality. Model cannot be constructed of anything. There exist systems where the simplest model is the system itself. Modelling in this case should just complicate the situation. In this sense there are explicitly good models but it's well known that there are also wrong things which, by modification, may work well. Model is evidently a model and not the reality but the abstracted copy of it from which we try to conclude to the reality and in the case of any mismatch we have to change the model. [1]

In studying biological models we should like to identify regularities between numerous internal and external factors. According to our professional experiences, we choose those factors (constituents) supposed to play the most important role in the given biological model and these shall become the so-called active factors. [2] Those factors, on the other hand, bearing – in our recent knowledge – a negligible role in the given study are the so-called passive factors. The proper thing to do on behalf of the biologist would be to ask for the help of the physicist when collecting concrete biological facts and discussing results as one goes on. The physicist advises many a time to do this and that.

Modelling

Every science has central questions, such key issue in biophysics is the model forming. For the model we understand a mathematical or physical construction (function, formula, interrelation) which describes the observed phenomena by adding certain verbal explanation. Such a physical construction will be exclusively and exactly justified if it is expected to work – i.e. properly describes phenomena in a rather wide range.

The biologist has to abstract parts of the biological process substantial from the point of view of the model and has to select those essential points the physicist willingly accepts and in which he will be ready to collaborate. Hereupon as a rule, the physicist used to suggest an already existing model of the wide arsenal of the physics applied for the description of natural phenomena. [3] If there is a physical model disposable for the biological phenomenon then it will bring up a lot of possibilities offered by the physics to the biology which, of course, must be subjected to biological-logical judgement. From many of them turns out that it's worth dealing with and being subjected to biological experimentation. If our supposal has been justified by the biological experiment then we have got new knowledge in the long run. In this case model has given even more than it was originally forseen. In this respect, it's without doubt that the biological modelling is a useful way of collaboration between the biologist and physicist.

Biophysical model can help to see certain phases more clearly and sharply giving way for experimentation. If you cannot get the features expected by the researcher then it is just the model to be wrong. But by all means, the biophysical model is always suitable to correct faults and direct further investigations in the proper way. [4]

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. This contributes to increase the professional knowledge by which passive factors become active ones but it may turn out that some active factors were in fact passive ones. Here, the biologist must be careful whether he should accept the model or wants to make modifications.

We should steadily see also the strict limitations of the mo-delling. Part of these limits is intensive and is best perceptible with the comparison that if we have a closer, focused look at an object it will necessarily get blurred or even disappear all beyond the scope of our observation. The other part of the limitations is extensive, the majority of the today's models cannot take into consideration more but some distincted features. The mesh of the extensive and intensive limits, the complexity, underlines even more the necessity of modelling but it assures the conditions of the controllable advancement in a complicated spiritual (intellectual, mental) medium. [5]

Forming a biophysical model is not the task of the biologist or phycist alone, a good model can successfully constructed only by common, collective work. This is typically the task of the biophysicist and a problem which falls within the competence of this discipline. Model is always an approximation, the user of the model has to take into consideration that he can approach only the absolute truth just through the endless series of relative truths. For this reason, he performs certain neglects in advance, he disregards certain things. The model is nothing but an abstracted phenomenon, a momentarily stopped biological system. [6] As soon as it has got a model it ceased to be alive but this should not exclude a model be built and the results of the biophysics be applied.

The obvious key issue is how single models co-here, in what extent and in what way they can be related? If we rightly imagine that research is an answer-to-question game with the nature and the single disciplines, groups of problems are characterized by certain classes of questions, then it is evident that models originating from identical classes of question should be included in the same model-families. Moreover, if members of a model family can be transferred into each other unequivocally enough then we can speak about a theory-forming model system. It is the intention of the biophysics to elaborate model systems ever more unequivocal and of ever wider validity.

Biophysics, therefore, applies the methods of the physics. The biophysical approximation of the life processes leads always to the application of some kind of physical model. On the track of its inner development numerous fields of the physics have been established which can be utilized in the physical analysis of the biological processes, which are discovered, taken over and applied by the biophysics. [7] By raising questions to be solved, the biology demarcates field of action for the biophysics this, on the other hand, contributes to the biology getting a more exact science.

The biophysical approximation of the life processes leads always to the application of some kind of physical model. This model usually carries just some features of the process but complies the requirement of the accuracy. Accuracy is nothing else but to search for axiomata for a complicated life process and it‘s usually a great deal of work. Exactly from these difficulties germinates biophysics. The development of the biophysical science can be appraised on that we succeed in the investigation of ever complicated processes. Accordingly, in the research one must declare the axiomata of the deductive theories achieved by the study of the processes. You should clearly start with very simple examples. Again, the more complicated life processes we tackle, the higher we raise the scientific level of the biophysics.

This wide liberty of choosing axiomata is yet limited in reality by the usefulness of the theory. 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. [8] The lesser observations or experimental results have been left over the estimation stacks deducable from the biophysical axioma systems the more exact the biology becomes to be. 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 the Nobel prize winner genetician: „Biology is too important to be left just for the biologists."

Taking into account the above said we may state that the exactness of the biology can be approached from two sides. One side is meant the inner development of the biology which proceeds along a spiral line expanding evenly in breadth and depth offering thus an image more true to the nature. The other side implies the border sciences come to light from the biology out of wich biophysics has got a very important role. All these are still in their „ infancy", biology is going ripen for exactness but we are still at the beginning of the process. It is hoped that still in this century a quality leap in this direction shall come to pass so that we can affirm that in the future's axiomatic biology life will be a fundamental conception without being defined.

The system

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. [9] 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: 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 outcome (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. 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 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. [10]

The order in the stochastic systems is of non-deterministic nature but events occur – subsequently from the essential kind of the system itself – with a probability less than one and may perform chaotic behaviour. The former method of demonstrating supposals fails simply because the hypothesis pertains not on the certainty but on the probability of the event. As a result, the successfulness of those methods dealing with the special systems and with the empirical investigations in the physics may be regarded as a fortunate accident owing really to the fact that the systems studied were large enough (not as those of Heisenberg where the information is of the same order of magnitude than the system and the observation is part of the system) having a very insignificant probability character.

For practical reasons, let's circumscribe the concept of the system more exactly as such an arrangement of the constituents which serves to reach the concrete purpose according to a certain programme. This definition has three essential factors. In the first place, it should need an object to be realized by the system. Secondly, it is necessary for the components a well-defined settlement to be arranged. At last the information about the distribution of energy and matter according to the programme. Thus any physical entity can be considered as a system if the output (outcome) of its behaviour will be conceived as the result of the interaction between the parts. Many entities, therefore, can be treated both as elements and as systems depending on the decision of the investigator.

The biological system can be described at least to some extent as a self-regulatory system. Its four essential characteristics are as follows:

1. Its elements have the disposal of life as an attribute.

2. There is structural link between its components. Thus for example, the nutrition is connected with the circulation and respiration and with the excretion as well.

3. The subgroups of different function are aware of each other's behaviour through communication. This is mainly realized by the nervous and the endocrine system.

4. The living system has certain liberty of selection in respect to the ways of action and also to the goals (the result expected). In the interest of its self-preservation, it can select between foods, choose living space in the environment and a mate for the race-preservation.

Shortly speaking the four essential feature of the living systems is the sum of the content components, the structural construction, the communication and the ambiguous but interval parameters realizing the functions.

It must be stressed by all means that the system is always just an approximative modelling but it enables us the better recognition of our environment and ourselves as well.

The hierarchy of the systems

The approximations of the investigations between the branches of science by interdisciplinary attitude clearly show the increasing interest for joining the knowledge into systems of wide spectra. If we don't want the research between the branches of science to lead into limitlessness then we have to elaborate systems for the integration of the independent branches within which they can still maintain their distinctive character. [11]

The hierarchy of the systems will be built up according to a spiral line expanding in breadth and depth towards the infinity. Although the idea of the system and the necessity of builiding-up systems is not new-fangled (updated), systems were not enough stressed in the sciences for a long time. Though as a result of the significant discoveries at the beginning of our century, a break-through has been achieved both in the field of physics and of mathematics, yet these were the last decades when the interdisciplinary attitude came across also in the biology. But in addition there was a considerable contribution by the rapid development of other sciences like mathematics, physics, chemistry, technical sciences because their discoveries, methodologies and tools gave way for the biologists to probe deeply enough into the recognition of the living material. At the same time, the results of the sciences penetrated stimulating and inspiring the biology in the form of analogy and terminology. [12]

One important mode to construct general systems is if we recognize the common phenomena occurring in the different specialized sciences and construct the systems applicable for such phenomena. The second construction mode would be to arrange the systems in a hierarchic system. This in the same time would result in fixing the abstraction levels corresponding to the different degrees. This cannot be realized unequivocally. The second construction mode, the hierarchy of the levels will be investigated in details.

Generally speaking the different levels cannot be delimited unambiguously and it is the investigator to separate them artificially due to methodological reasons. Systems are not divided into sub-, super- and co-ordinated relations, respectively, in a well determined manner but they appear intermixed in the structural hierarchy. Let's sketch out the hierarchy of the systems according to Boulding as follows:

1.) The first level is that of the static structure. It could be called the level of the shells (skeletons). It is really the geography and anatomy of the universe: the localization scheme of the electrons around the nucleus, the scheme of the atoms in a molecular formula, the settlement of the atoms in a crystal, the anatomy of the gene, the cell, the plant, the animal, the map of the Earth, the solar system, the stellar world. The organized theoretical knowledge starts with the exact description of these shells on almost every territory because no functional or dynamic theory can exist without this accurate description of the static conditions.

2.) On the second level you can see the simple dynamic system with its predetermined, necessary movements. It could have been called the level of the clockworks. From the human point of view, of course, it is the solar system as the great clock of the universe and the imposingly accurate predictions of the astronomers to bear witness to the excellent quality of the clockwork applied. Mechanical powers can be usually interpreted on this level, like the lever and the pulley but also more complicated machines like the steam-engine and the dynamo (generator). To the same level belongs the physics, chemistry and even the major part of the theoretical constructions of the economy, too.

3.) The next level is the steering mechanism or cybernetic system which could be otherwise called the thermostat level. This differs from the simple stationary equilibrium system in that its substantial part is the transmission and processing of the information. The equilibrium, therefore, will not be simply determined by the equations of the system but the system itself seeks to maintain – within limits – a certain equilibrium. The greatly important homeostatic model in the physiology is only one example for the cybernetic mechanism but the whole world investigated by the biologist and sociologist is full of such mechanisms.

4.) The fourth level is the „open system” or the self-sustaining structure. On this level the living begins to separate from that which is not living: this could be called the level of the cell. If we fall in with systems being able to reproduce and sustain themselves during matter- and energy-perfusion then we have to deal with something of the kind which we hardly can deny the name „life”.

5.) The fifth is the level of the genetic society the typical form of it rules over the flora and the empirical world of the botany. The major characteristics of this system are first the cell population formed by division of labor between the cells with its differentiated and mutually interrelated parts (roots, leaves, seeds, etc.), secondly a sharp separation between genotyp and phenotyp which is related to the one-aimed or programmated growth.

6.) Going upwards from the flora to the fauna gradually we reach the „animal” level which is characterized by motility, specific behaviour and by self-identification. Here special information-receivers are developing (like eye, ear, etc.) and as a result, the information-uptake grows enormously. In addition, the nervous system increasingly develops, after all the brain as the organ which organizes the information into structural knowledge or „image”. Going upwards on the scale of the animal life, the behaviour becomes not only a reaction to any concrete stimulus in an ever raising degree but an answer to an „image” or structured knowledge or attitude formed from the environment as a whole. This image will lastly be determined, of course, by the information taken up by the organism, however, the relation between information-uptake and imaging (the construction of a picture) is extremely complicated. The process is not simply the accumulation of the accepted information – although it is often the case – but it will be structurated in a manner which essentially differs from the information itself. Once the image-structure has been definitely formed the new information will hardly change on the picture: it quasi passes the loose structure without „colliding” with whatever. The image sometimes „catches” the information incorporating it, sometimes the information comes into collision with any core, „nucleus” of the image so that its whole will be transformed in a way that a seemingly inconsiderable stimulus will provoke a highly significant reaction, that is to say, the behaviour will change considerably and radically. Thus the determination of the future behaviour of such systems will be aggravated, namely by the picture intercalated between the stimulus and the answer.

7.) Follows the „human” level, that is the individual human being comprehended as a system. Man is probably the only organism which knows that he will die, which takes into account – by forming his behaviour – his full lifespan and even more of it. Man exists not only in a given time and space but in history, too, and his behaviour will be deeply influenced how he sees the course of time he lives in.

8.) The social level. The fundamental level of such systems is not even the individual – the human being as such – but the „role” that is those circumstances of the personality which are in relation with the organism or situation in question. What should be investigated on this level? The content and meaning of the informations, the nature and dimensions of the systems/scales of values, the transcription of images into history, the embarrassing and delicate symbolics of the fine arts, music, poetry.

9.) In order to complete the hierarchy of the systems still we have to include the level of the psychical systems, too. There are also other aspects to classify our environmental world. Below, you will find some other hierarchies of the systems. Such kind of representation of this hierarchy has, among others, the advantage that it offers some idea about the shortcomings of our present – theoretical as well as practical – knowledge.

Matter is known to exist of two fundamental kind: that of discrete nature, of corpuscular structure and those physical domains/fields displaying steady feature and transmiting interactions between material parts. The particles of corpuscular character and the physical domains can not be sharply separated from each other, there si no impassable barrier between the two outward forms of the matter,they can transform in each other. Under certain circumstances, these outward forms of the matter posses similar features, corpuscula generate spaces of different type, display continuous wave character, on the other hand, domains may have manifestations characteristic of particles.

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