New methodology in biomedical science: methodological errors in classical science

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Key words: *biomedical science, methodological errors, systemic and evolutionary methodology, non-linear, holistic, complex way of thinking.*

Summary. *The following methodological errors are observed in biomedical sciences: paradigmatic ones; those of exaggerated search for certainty; science dehumanisation; deterministic and linearity; those of making conclusions; errors of reductionism or quality decomposition as well as exaggerated enlargement; errors connected with discarding odd; unexpected or awkward facts; those of exaggerated mathematization; isolation of science; the error of "common sense"; Ceteris Paribus law's ("other things being equal" laws) error; "youth" and common sense; inflexibility of criteria of the truth; errors of restricting the sources of truth and ways of searching for truth; the error connected with wisdom gained post factum; the errors of wrong interpretation of research mission; "laziness" to repeat the experiment as well as the errors of coordination of errors. One of the basic aims for the present-day scholars of biomedicine is, therefore, mastering the new non-linear, holistic, complex way of thinking that will, undoubtedly, enable one to make less errors doing research. The aim of "scientific travelling" will be achieved with greater probability if the "travelling" itself is performed with great probability.*

Introduction

The power of science paradigms is enormous. In other words, our comprehension of things depends on the way we look upon reality. Paradigm, as disciplinary matrix, is a set of answers to such questions that are learned by scientists in the course of the education that prepares them for research, and provides the framework within which science operates (1). The paradigm of classical science that has been dominant since the time of Newton to the present-day cannot account for behavior of complex dynamic non-linear phenomena accounted for in biomedical science (2–9). A hallmark of biomedical systems is their extraordinary complexity. It has been shown that the non-stationarity and non-linearity of signals generated by living organisms defy traditional mechanistic approaches based on homeostasis and conventional biostatistical methodologies (5, 10). Recognition that physiologic time series contain "hidden information" has fuelled growing interest in applying concepts and techniques from statistical physics, including chaos theory, to a wide range of biomedical problems from molecular to organismic levels (5, 11–13). Attempts are made to fill in this gap by the systemic and evolutionary (SE) paradigm that urges one to courageously face the reality and abandon "deterministic nightmares", quality decomposition as well exaggerated research powers and methodological monism (14–16). Thus, nowadays in order to solve a great many problems of biomedical science it obligatory that the research methodology be changed it is necessary to turn from mechanistic classical linear methodology to non-linear complex dynamics science methodology (2, 5, 11, 17–19). According to V. Tasic (13), presently we witness "science wars" taking place between methodologies and the outcome of these processes will greatly depend on the science being revised.

The main aim of this study was to review the basic methodological errors made in biomedical sciences due to the rooted prevalence in science of the classical deterministic paradigm. We think that our study is to be continued. Our next paper will be devoted to the study of the basic features of the new methodology of biomedical science.

Methodological errors

1. Paradigmatic errors

Since the times of Newton a stunning progress in the new research fields, such as cybernetics, general systems theory, artificial life system dynamics, cellular automata (self-reproducing automata), catastrophe theory, chaos theory, theory of complexity, theory of

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punctuated equilibrium and self-organization, as well as the theory of stochastic processes, etc. has taken place (12, 20–25). According to S. Kellert (26), chaos theory is "qualitative study of unstable non-periodic behavior in deterministic dynamical systems. P. Rapp (27) considers that chaotic systems share three essential properties. First, they are dramatically sensitive to initial conditions. Second, they can display a highly disordered behavior. Third, despite this last feature they are deterministic, that is they obey some laws that completely describe their motion. It is on the results obtained from these fields of research that the solution of problems of organized complexity is based. The field studying complex, dynamic and evolving systems is a young one, and as such not very well established.

The system and evolutionary (SE) paradigm enables one to grasp the challenges of the "new world" more clearly. The SE paradigm embodies new "scientific literacy" and new science culture distinguished by such essential features, as critical thinking, continuous search for truth as well as perpetual dialogue with "nature", man and society (15). It is a paradigm of complexity, diversity and emerging dynamics (19, 28–35) (Table).

***Table.* Basic properties of the classical (deterministic) and the new (systemic and evolutionary) paradigm**

No.	Classical (deterministic) paradigm	New (systemic and evolutionary) paradigm
1.	The aim of science is to find absolute truth	The aim of science is to draw nearer to truth or "to live" between truth and untruth
2.	Truth is objective	Truth is dependent on the "weaknesses" of the observer
3.	The object of study is orderly, predictable, stable, governed and closed	The object of study is dynamic, spontaneous, multi-stable, self-governed and open to changes
4.	The system is precisely defined and forecasted	The system can neither be precisely defined nor forecasted
5.	Truth is but what corresponds to the facts	Truth is what with higher probability shows being closer to truth
6.	The whole consists of parts; on the basis of the part it is possible to judge about the whole, and vice versa	The whole is more than the sum of the parts; knowledge of the parts does not mean knowing the whole. Interesting wholes can arise simply from interesting parts.
7.	Linear and one-sided dependence of cause upon effect. Linear causality: emphasizes past and content	Dynamic mutual (circular) dependence between cause and effect. There is a reciprocal causal relationship between parts and wholes. Circular causality: emphasizes present and process
8.	Holistic properties may change but logically and step-by -step	Holistic properties may suddenly and apparently mysteriously change
9.	Change necessarily indicates the existence of an outside agent or force	Change does not necessarily indicate the existence of an outside agent or force
10.	The relation between parts and the whole does not change for a given whole	The same change in element property or behavior may have a small effect on ensemble order at one time and large effect at another time
11.	Interesting wholes can arise only from order	Interesting wholes can arise from chaos and randomness
12.	Randomness cannot explain behavior of wholes	Randomness plays an important role in the explanation of possible wholes
13.	Intellect is omnipotent	The power of intellect is limited
14.	The cause is always local and defined	The cause is always global and dynamic
15.	There is but one (the best) methodology	There is no single best methodology – there is but a mixture of methodologies
16.	The structure gives rise to the process	The process gives rise to the structure
17.	A single one fundamental level of reality	Many fundamental levels of reality

The new science paradigm urges one "to study Nature…and languages of complex systems" since they "converse with us not in one but in thousands of languages" (15). Furthermore, the SE paradigm warns us that the study of complex adaptive systems (CAS) by means of merely one "language" is nearly always bound to meet with failure. Thus, the CAS should be studied from different angles since it is versatile in meaning, dynamic and spontaneous one. According to I. Prigogine (15) Nature is never likely to give away a lie if it "is driven into a corner" by accurate questions. The systemic and evolutionary paradigm urges one to regard the world through the eyes of dynamics of possibilities and their probabilities (15). The world amounts in a far greater number of possibilities than realities. Every possibility is a potential reality and turning possibility into reality is conditioned by numerous factors the sum total of which is impossible to appraise. It appears that the probability of occurrence of this or that property of CAS manifestation is a dynamic one, i. e. variable in time. The classical science paradigm recognized but importance of necessity, whereas the SE paradigm has enabled one to believe that manifestation of any single occurrence is dependent on certain probability and chance occurrences. It might be said that concrete sense of some property of the CAS always manifests itself solely with some definite probability. The regularity (frequency) of occurrence of some event may be low but with high probability.

Traits of the new science paradigm, systemic and evolutionary (SE) one are as follows (9, 15, 21, 24, 29, 31–33, 35)**:** 1) The "flatness" and "roughness" of searching for truth – searching for truth is by far more effective if one travels not top-down but bottom-up…towards overall properties of the whole. In other words, the SE paradigm relies rather on holism than on classical reductionism. 2) It is obligatory that not everything but the aggregate property of the whole be studied though it is extremely important to ascertain what the most important property is. 3) Disappearance of the local causality, since the cause as such is rather a "global" phenomenon. 4) It is impossible to accurately establish the initial state of CAS in principle (the principle of indetermination) ("nobody has ever observed and will never observe a person in its wholeness at a time"). 5) There are no objective properties that would not be completely dependent on the "weakness" of observer.

Contrary to the classical science paradigm the SE paradigm realizes that the mission of science is rather "traveling" than "arriving". Therefore, according to the SE paradigm, the basic aim of science is not revealing the universal truth since it is impossible to attain but rather drawing nearer towards clearer understanding of reality at the same time showing its versatility, complexity and uncertainty (6, 9, 12, 15, 22, 30, 35). Besides, drawing nearer to clearer understanding of reality may be of two kinds: a) making uncertainty more certain and 2) expanding the boundaries of knowing. The systemic-evolutionary paradigm may be said to stimulate constant learning. The one who decides that there is nothing more for him to learn falls out of "the game of science".

The SE paradigm emphasizes the fact that the entire process of cognition becomes a hypothetic one since its constituent parts, i. e. separate statements or assertions may be true but in principle they can always be revised and sometimes be discarded altogether. No wonder that constant doubt is sure to penetrate into everyday life and science.

The world, biomedical reality included, is neither predetermined nor given in advance (as thought by determinists), nor modeled according to a certain "project of engineering" (as thought by creationists), but it rather evolves (as thought by evolutionists). The world, in many cases, evolves, as it were, spontaneously, not directly, but necessarily originally, i. e. giving heed not only to its inner goal but to spontaneous "escapades" of the surroundings too (9, 12, 20, 24). All this is applicable in biomedicine science.

2. The error of striving for exaggerated certainty

Scientific realist believes that truth can be discovered objectively, irrespective of the subject and the weaknesses of theories created by him. It is maintained that accurate forecasting of either onset or end of the dynamics of complex adaptive self-organized system (CAS) is not possible in principle (2, 9, 13, 15, 20, 25, 33). The CAS, as a deterministic system, operates but in certain stages (Fig. 1) and, most frequently, in certain artificial conditions, that cannot be directly transformed to natural conditions. The behavior in natural conditions can differ in principle from artificial, laboratory-like conditions. The CAS is a determined one but locally…in "deterministic windows". In other words, forecasting the CAS behavior, if possible at all, can be realized but in "short bits of time" (in deterministic windows) with full awareness of the fact that every trifle can bring every forecast to nil. According to one of the newest interpretations of entropy it is a measure of chaos, i. e. order difficult to comprehend. In other words, entropy is a measure of

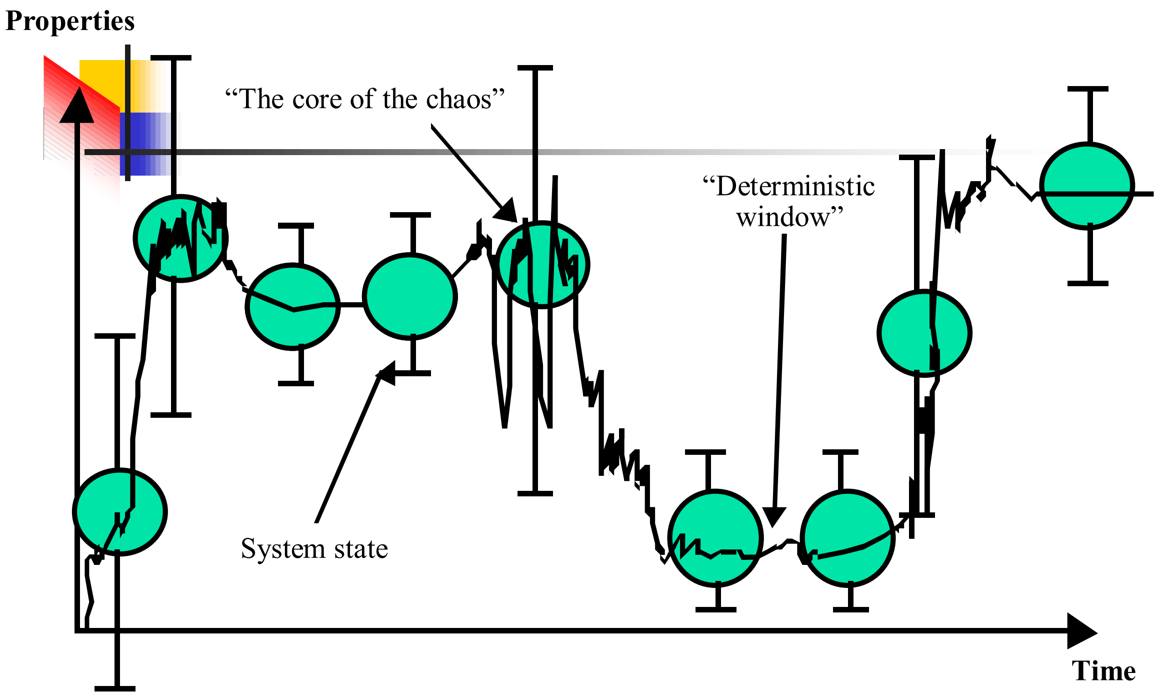

Fig. 1. **Behavioral peculiarities of a complex adaptive dynamic system**

uncertainty (15, 20, 24). If the scientist (the subject) understands the behavioral regularities of the system more clearly then he sees the system as less complex (the entropy of understanding decreases). This does not mean, however, that the system itself has become a less complex one. When the state of chaos in the behavior of the system increases, then an increase in the entropy of the system takes place as well. The search for absolute certainty, where it cannot exist in principle, is one of the greatest errors made in research nowadays.

3. The error of science dehumanization

The researcher is not "a deterministic system". Therefore he inevitably makes the following errors: 1) he is incapable of making an accurate choice of the object of research (there is no way of enabling one to objectively choose the object of research, since making a choice is a psychological and qualitative act; whether we study a mechanism or the dynamics of system behavior or the process of learning the system depends but on the intentions, aims, experience, etc. of the subject); 2) he cannot make objective choice which property of the object should be studied; 3) it is difficult to choose an optimal way of research that would be best suited to reveal property under investigation of the object studied; 4) the accuracy of data processing depends on the weaknesses of the researcher too and, finally, and 5) the researcher inevitably makes errors in generalizing the results of the research, as well as in making conclusions. It might be said, that the sources of these five errors made by the researcher are practically inexhaustible, i. e. the researcher is sure to make and will make errors of this type irrespective of the fact if he is a beginner or more experienced in this field. In other words, irrespective of the fact that with each time we are capable of collecting ever more reliable and accurate data we remain unprotected from the subjective errors made by the researcher. Another source of concern in biomedical community in recent years has been the problem of scientific misconduct (36), including the publication of fraudulent data.

4. Deterministic and linearity (linear thinking) errors

Biomedical science is a science of complex adaptive dynamic non-linear systems (6, 7, 29, 31, 37). It might be asserted that the object of biomedical science is more complex and more non-linear, than, for instance, that of engineering. The law of dynamics is, undoubtedly, one of the most important laws of the CAS since it describes the properties of the CAS behavior occurring with the highest frequency: the behavior of the CAS emerges in accordance with the same results each time and, if it so happens, that the same property emerges once again, its emergence, most likely, takes place according to different rules (8, 14, 20, 25). In other words, the law of dynamics asserts that there is no direct and deterministic connection between the factors affecting the system and system response to the factors in question. It has been known that the same change in element property or behavior may have a small effect on ensemble order at one time and large effect at another time. The regularity of the CAS behavior can be understood only in the context of other regularities. Every law is operative but in the context of other laws. If one of the laws is being adjusted the other laws must necessarily to be revised as well. Many laws may be said "to be bound" by a number of ties in such a way that breaking one of the ties brings about a change in the entire "structure of laws".

5. Errors in making conclusions

A) The error of the inductive conclusion. Induction is the art of generalizing observations (38). An example of naive induction: if all "Xs" observed have properties possessed by "Ys", i. e. not a single "X" has been found not to have properties possessed by "Y", then an inductive conclusion that "All "Xs" have properties possessed by "Y" is made. Induction is a way of searching for probability truth. Why do we search for the truth with probability amounting to 95 per cent? Can an inductive conclusion with probability amounting to 50 or 75 per cent be truthful? What should be done in biomedicine with phenomena that manifest themselves with 50 per cent or even smaller probability: are they not important at all? Or are they important but unreliable? Or is it a true fact that there always remains a certain inaccuracy due to which every generalized conclusion can be brought to nil? Thus, it might be said that the errors of induction, likewise a great many of other methodological errors, occur because of exaggerated faith in the power of induction when making generalizations and conclusions about phenomena.

B) The error of making a deductive conclusion occurs because of our exaggerated faith in the human reason and the laws formulated earlier. The power of the human mind is not infinite, exactly like a law is powerless to explain all facts. Still on the basis of the human mind, as well as theories or laws formulated earlier, and with all the facts available we cannot make absolutely accurate conclusions in principle.

6. Error of reductionism (errors of quality decomposition and exaggerated enlargement)

The error of quality decomposition. It might be said that the error of reductionism or quality decomposition is rooted in the reasoning of scientists and research methodology the most deeply. The traditional approach to human biology and medicine is reductionistic, organizing bodies of knowledge into individual organ systems and explaining health and disease as the absence or presence of specific abnormalities of these organs. However, because the human body is a complex system, its function in health and disease cannot be fully explained by an understanding of its component part (17, 39).

We can still frequently come across the opinion that "the more details we know the more profound our knowledge is". It has been observed, however, that the behavior of separate parts does not allow one to judge of the behavioral peculiarities of the whole. The whole, therefore, is not the sum total of its parts and, in case the "sum total" does exist, it is, for certain, non-linear, spontaneous and recurrent but rarely (18, 34, 35). The basic question enabling one to get rid of "nightmares" of reductionism is as follows: is it possible, and if so, then when and how, to explain the behavior of the whole without dealing with the parts of the whole? Thus, the classical science of biomedicine has to change its understanding that the whole can be recognized only in the case when it is split up into parts towards understanding that in order to grasp the behavior of system any phenomenon should be investigated not only top-down but rather applying a mixed method of analysis, i. e. both top-down and bottom-up ("chaotic itinerancy") (Fig. 2).

The greatest error possible to be made in the biomedicine science is when the whole that comprises one single quality is being split up. There is no doubt that biomedical science is a science of quality rather than of quantity. In such a case even though one comes to know certain parts of the whole the quality itself is

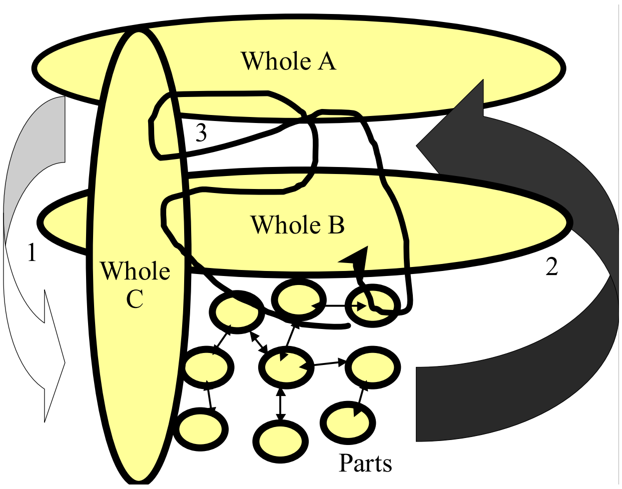

Fig. 2. **Three ways of searching for certainty**
1 – top-down, 2 – bottom-up, 3 – "chaotic itinerancy".

beyond one's comprehension. The scientists, supporters of the classical paradigm, keep on searching for some fundamental mechanism the cognition of which would enable one to understand the behavior of the whole as though the behavior of the whole were the sum total of fundamental mechanisms. It is a tremendous error in world outlook that the biomedicine science fails to overcome. It is high time scholars engaged in biomedical research understood the fact that there exists a number of parallel levels of research: from mechanism towards adaptive behavior. We are used to searching for "atomic mechanism". The living systems, however, with the numerous "atomic mechanisms" available turn out to play "a different game" each time when the surrounding conditions (the context) are exposed to changes. Though the macro world is formed from the micro world there is no doubt, however, that the micro world "plays" according to other rules than the macro world. Thus, if we ascertain the rules of the micro world, e. g. the rules of "the game" used by the cells, it does not mean, however, that we already know how the whole organism (human being) "plays", especially in dynamic environment. Therefore, in order to understand the behavior of the whole, it is obligatory to perceive not only the behavior of its parts but also the logic of the interconnections between the parts. The whole system has self-organizing properties that transcend the properties of its parts, a feature that arises from non-linearity. The emergent order is holistic in the sense that it is a consequence of the interactions between the component elements of the system and is not coded in or determined by the properties of a privileged set of components (8, 9, 13, 39). We see that there is no privileged part of the organism that has the instructions to make a whole from parts. This is why reductionism fails in complex systems. Therefore the science of biomedicine might rather direct itself towards perception of the whole, though sometimes "blurred" than towards a clear understanding of parts. Which is better: the whole, though "blurred", or a part of the whole, however lucid it might be?

The error of exaggerated quality enlargement occurs when, likewise in making an inductive conclusion, an attempt is undertaken to make up and generalize an integral quality out of separate "quality pieces". Is it possible to create a "medium" human face basing oneself on all human faces the world over? Yes, it is possible to do so but none of us would be able to recognize himself.

Why have the scientists started splitting the reality into separate smaller pieces? I think that they have been doing it because of two main reasons: a) scientists believed and, frequently, still believe that it is possible to discover some ultimate mechanism, some particle, that would enable one to cognize the reality as a whole; b) scientists were happy about being able to discover more and more, i. e. they thought that the more mechanisms one discovers the more profound his knowledge is. Unfortunately, according to R. Feynmann (14), truth is much more simpler that search for truth.

Why have the scientists become so enchanted by the generalization of the data obtained? I think that they believed too strongly in the power of unification and simplification. It was already Albert Einstein (40), however, who had voiced an idea that there was great danger of exaggerated unification and simplification. Therefore, even today, there is no clear-cut answer to the question what should be the corpus of the data collected and how they should be generalized not to lose very important information.

7. The fundamental error of the classical science lies in the fact that only the entities that can be counted are regarded as data

This leaves out a great many qualitative effects and phenomena of life. The dimension of life is surely non-quantitative but rather qualitative one, permanent creative work being its basic dimension. The science of biomedicine has not sufficiently assimilated yet the non-linear dynamics methods of doing research in complex systems that are characterized by peculiar indications of chaos. Therefore greater attention should be given to these four quantifiers of non-linear dynamic complex systems (chaos): 1) Lyapunov exponents, 2) Kolmogorov entropy, 3) fractal dimension, 4) correlation dimension (5, 11, 24, 41). In researching living systems it is of importance, first of all, to understand the quality investigated, since quantitative measuring is possible but in the same quality. Quantitative comparing loses any sense if it is used when comparing different qualities.

8. Ceteris Paribus law's ("other things being equal" laws) error

A theory is a body of laws that work together to explain phenomena. Therefore, however perfect the law might be, taken alone it cannot explain the behavior of such a complex system as a living organism. The more so, even if we find out all the necessary laws but we do not understand how these laws work together we will not be able to understand the behavior of the system either. In other words, the certainty of the behavior of the phenomenon is not proportional to the sum-total of all the laws taken separately. Therefore, the scientists of biomedicine gave their attention to the fact how the laws work together. Pure regularities of the behavior of living systems or their parts hold true but in conditions of Ceteris Paribus (15, 38). In real practical conditions these laws either do not operate at all or operate in the concealed or distorted form. The scientists, therefore, are faced with a difficult problem, namely, what kind of laws they should be searching for: clear-cut but operating in conditions of Ceteris Paribus or less clear but operating in real conditions. The classical science paradigm strives but for certainty. Therefore it selects Ceteris Paribus thus confining science to laboratories, i.e. tearing it off "the life context of living systems".

9. The error of discarding strange, unexpected or awkward facts (the error of disregarding facts of accidental nature)

This error might also be interpreted as the error of fear of reality. This error is caused by striving for exaggerated certainty at the expense of simplification of reality or due to Ceteris Paribus. The error of disrespect for facts of accidental nature is closely related to the paradigmatic error, which maintains that the classical paradigm urges one to search for absolute certainty (15). This error manifests itself in the fact that the researchers treat these strange, unexpected facts as facts of accidental nature or research errors and they simply discard them or increase the number of facts so that these "strange facts" should not have a greater significance (42). Unfortunately, in the behavior of living systems these unexpected and strange indications or properties take a special place, since it is they that might exert the greatest influence on the direction in the behavior of the whole system (30).

10. Error of exaggerated mathematization

This error lies in the presently prevailing opinion that modeling phenomena of reality is possible but with the help of mathematical models. The consequences of this error are evident when the scientists do their best to mathematically describe phenomena at all costs frequently without understanding the logic of their realization. A "mathematical instrument" should help one to clearer understand and explain the behavioral peculiarities of the systems and by no means it can be an end in itself (43–46). Traditional mathematics leaves no space for feelings, intuition, irrationality and spontaneity. Therefore it is still far from dynamic life. Besides, however precise mathematics might be, it cannot enable one to grasp the spontaneous behavior of the animate nature. Therefore all mathematical models, unless they are being constantly modified by practical experiments, lose their cognitive power. There is no doubt whatever that biomedical scientists should be aware of the logic of applying mathematics as well as its limits, likewise mathematicians should feel the logic of behavior of living systems. In other words, they should work together being the supplement of one another.

11. Error of isolation (it is an error typical for every kind of science)

It is extremely dangerous for biomedical sciences not to go deeper into the general (philosophic) regularities of nature, man and society behavior. Biomedical science should "feed" on the achievements of other sciences, methodological-philosophical and complex, non-linear dynamic ones in particular (5, 9, 27, 37). We have no doubts whatever that scientists of biomedicine could provide a great many of ideas enabling us to understand living systems and thus get in closer touch with art, music and poetry. The science of biomedicine can be understood more clearly if studied in the context of social, physical sciences and the humanities. In other words, laboratories should borderless ("laboratories without walls") and the data should be open (10). If there exist some boundaries in science they are extremely dynamic and subjective and, what is most important, they should not hinder laying bare the truth, the act that has no boundaries and does not recognize them indeed.

12. Errors of "youth"

The error of "youth" is conditioned by the young age of science and the most striking symptoms of this errors are as follows: lack of respect for theory and hypothesis and the critical method of search for truth, poor capacity of forecasting phenomena and lack of modesty in interpreting research data and presenting practical conclusions. The science itself is a young social phenomenon that due to its "youth" frequently thinks that it is omnipotent, namely, that it is the only source and means of cognition. Still there are many more other sources and means of cognition alongside with scientific cognition.

13. Error of "common sense"

Scientists frequently create such "logical worlds" that are extremely remote from reality, the "worlds" that nobody has ever seen and, possibly, will never see. They say that in such cases "common sense" is no longer there. The problem of common sense is associated with the purport and value of research (16). The most important question raised by scientists, therefore, should be as follows: what and why should be studied? Still is it always that "common sense" helps? On the contrary, the scientific description suggests that common-sense reality is an illusion, or at least that we certainly don't perceive the world to be anything like the way it is in certain respects.

14. Error of inflexibility of demarcation criteria of the truth

The traditional criteria of definition (demarcation) of scientific truth – verification, confirmation and falsification – do not appear to be completely reliable or "immovable pillars of scientific truth". It could be said that these three strongest demarcation criteria of scientific truth pose the following questions: 1) can the research be reliably verified and reproduced? 2) is it possible that the conclusions of the research be falsified when carrying out the research in different conditions? 3) are the conclusions of the research based on logic and common sense, as well as supported by sufficiently reliable facts? It is frequently, therefore, that scientists eager to advance to forward by revealing new phenomena "catch at a straw", as it were, i. e. they rely on very fragile and subjective criterion of truth – the judgment of experts, i. e. on mutual agreement of the latter. The SE paradigm realizes that in most cases it is possible and necessary to resort to classical criteria. Still one cannot help wondering what should be done when we frequently witness these criteria to turn into artificial obstacles when striving for greater clearness. Then one is forced to make a choice between two possibilities: either to stand on solid ground without searching for certainty or to advance forward towards truth disregarding the arising inconvenience and uncertainty. The SE paradigm urges one to take risks and to give courage to the venture being undertaken, urges one to rely more on the opinion of the experts…irrespective of the fact, as it often happens, that they may have been mistaken.

15. The error of restricting the sources of truth and ways of searching for truth

The classical science of biomedicine is based on two principal ways of searching for truth, i. e. empiricism and rationalism. Still, alongside with them, scientists would obtain a lot of valuable knowledge if they tried to enlist the services of intuitive knowing and practical knowing too. In order to correct the error of "a narrow outlook" the science of biomedicine must, therefore, base itself on empirical knowing, and intellectual knowing, as well as intuitive knowing and sensuous knowing (33).

16. "Laziness" to repeat the experiment

There is no doubt that this error occurs because of "hastiness" to rejoice at the fruits of the research", because of disbelief that conclusions reliable may change when the experiment is repeated. Unfortunately, if biomedical scientists happen to repeat even the most reliable experiment in most cases they are likely to find a number of new things.

17. The error of "wisdom gained too late"

This error is rooted deeply among scientists because of immaturity of the methodology of research used. In other words, it often happens that scientists explain the conclusions of the research retrospectively, i. e. post factum. Thus, they do not explain in what way the results of research confirm or refute the research hypothesis formulated prior to the research undertaken but rather expound at great length what they have seen "during their traveling in research". In the first case there might be some difficulties, since one must have a sufficiently clear research hypothesis and it is not always that it is precisely confirmed. In the second case everything is rather simple – after carrying out the research something is found out and for every conclusion the explanation is not difficult to find. Since it is frequently that scientists choose a more convenient way of research, consequently, errors of "wisdom gained post factum" come to be made.

19. The error of wrong interpretation of the mission of research

This error manifests itself when researchers quite often come to believe in the power of research so much that they start thinking they have discovered the absolute and indisputable truth. Besides, this error shows itself in the fact that frequently scientists consider the result obtained more important than the way by means of which it had been achieved since they believe to have discovered the unique and the absolute truth. Actually, we should be more modest and prudent about our conclusions made and a far greater attention should be paid to the way by means of which our results have been received.

Another problem connected within an erroneous conception of science lies in the fact that classical science urges one to study order that contains far less information than that hidden in chaos – the complex order (Fig. 3). Besides, the purport of science is rather discovering the mutual arrangement of facts than registering as many of them as possible.

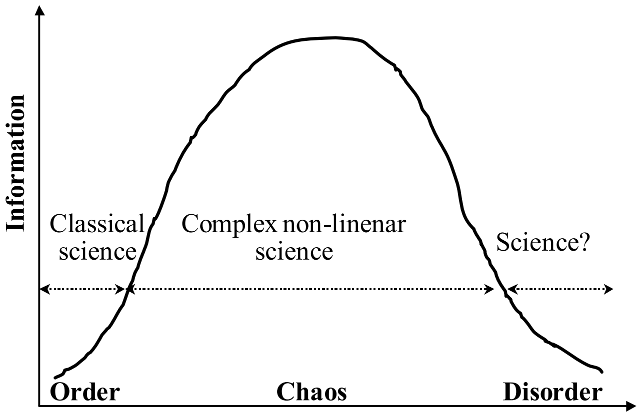

***Fig. 3.* Information hidden in order, chaos and disorder**

Classical science is oriented towards cognition of order, whereas complex non-linear science stresses cognition of chaos that contains the greatest amount of information. It remains not clear, however, how disorder could be comprehended and if it is possible to achieve it at all.

20. The error of "errors coordination" – or why is it difficult to do away with errors?

There is no doubt that all the errors presented above are in one or other way related, that is to say, they form a peculiar "system of errors". Consequently, correction of one error does not mean at all that this act will bring about a decrease in the whole "system of errors", since regrouping in the system will simply take place. In other words, research will not get "sound" until we ruin the entire "system of errors" as a whole. This does not mean, however, that another, perhaps more stable "system of errors", will fail to arise instead of the former one. Still is there any other way for us, scientists, except correcting errors and searching for the less erroneous method of research?

Conclusions

The following methodological errors are observed in biomedical sciences: paradigmatic ones; those of exaggerated search for certainty; science dehumanization; deterministic and linearity; those of making conclusions; errors of reductionism or quality decomposition as well as exaggerated enlargement; errors connected with discarding odd; unexpected or awkward facts; those of exaggerated mathematization; isolation of science; the error of "common sense"; Ceteris Paribus law's ("other things being equal" laws) error; "youth" and common sense; inflexibility of criteria of the truth; errors of restricting the sources of truth and ways of searching for truth; the error connected with wisdom gained post factum; the errors of wrong interpretation of research mission; "laziness" to repeat the experiment as well as the errors of coordination of errors. One of the basic aims for the present-day scholars of biomedicine is, therefore, mastering the new non-linear, holistic, complex way of thinking that will, undoubtedly, enable one to make less errors doing research. The aim of "scientific traveling" will be achieved with greater probability if the "traveling" itself is performed with great probability.

Nauja biomedicinos mokslo tyrimų metodologija: metodologinės mokslo klaidos

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Raktažodžiai: biomedicinos mokslas; metodologinės klaidos; sistemų ir evoliucinė metodologija; netiesinė, holistinė sudėtingų sistemų tyrimo paradigma.

Santrauka. Straipsnyje nagrinėjamos šios pagrindinės biomedicinos mokslo metodologinės klaidos: paradigminė, determinizmo ir „tiesinio mąstymo“, redukcionizmo arba kokybės skaidymo, perdėto apibendrinimo, išvadų sudarymo, keistų ir netikėtų arba nepatogių faktų atmetimo, perdėto matematizavimo, mokslo izoliacijos, mokslo „jaunystės“, sveiko proto, tiesos kriterijų nelankstumo, tiesos šaltinių arba tiesos ieškojimo būdų apribojimo, „gudrumo po laiko“, tyrimo misijos sampratos, klaidų koordinavimosi bei tingumo pakartoti eksperimentą klaidos. Šių dienų biomedicinos mokslininkams vienas pagrindinių tikslų – išmokti naujo netiesinio holistinio mąstymo, kuris įgalins daryti mažiau klaidų tiriant fenomenus, kurių pasitaiko biomedicinos moksle. Neabejojame, kad „mokslinės kelionės“ tikslas bus pasiektas su didesne tikimybe, jei pati kelionė vyks patikimiau, t. y. bus mažiau daroma metodologinių klaidų.

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