History of Medicine. 2017. Vol. 4. № 1.
DOI: 10.17720/2409-5834.v4.1.2017.08h

On the periodization of the history of medicine and scientific revolutions in medicine in the 17th–21st centuries

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This article expresses and explains the author's point of view on the periodization of the history of medicine from the 17th to the 21st century. To substantiate his view the author cites the main results of his study on the history of medicine in the Modern and Contemporary eras, which is based on the use of the philosophical-methodological concept of the structure and dynamics of scientific knowledge developed by V.S. Stepin for analyzing the history of medicine. The study showed that the historical process of the development of medicine from the 17th to the 21st century did not have a linear evolution related to the gradual increase of knowledge about the human organism and human diseases. In this period there were many cases in which the development of medicine was impossible without a radical review of the entire system of ideas on the subject of this scientific-practical activity and the methods for understanding it. These situations occurred either as a result of a systemic crisis related to the inner development of medicine itself or due to the influence of other fields of knowledge, which stimulated the study of phenomena that earlier doctors did not pay attention to. The scientific revolutions served as a way out of these situations. Each revolution led to a radical review of the ideas on the foundations of the biological process, the causes and essences of diseases and the approach to diagnosing and treating human sickness.

It is known for a fact that between the 17th and 21st centuries there were five disciplinary scientific revolutions, three of which were global and two – local. We will uncover the mechanisms of each scientific revolution and look at the results of the historical reconstruction of the reality, ideals, norms for the doctors' research activity and the philosophical foundations of medical science that accompanied these scientific revolutions.

Based on these results, the author proposes to distinguish five separate stages in the history of medicine in the Modern and Contemporary eras, each of which corresponds to one of the five scientific revolutions that took place in this period.

Keywords: *periodization, history of medicine, the scientific revolution*

For quotation: *Zatravkin S.N. On the periodization of the history of medicine and scientific revolutions in medicine in the 17th–21st centuries. History of Medicine. 2017. Vol. 4. № 1. P. 73–81.*

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In the "Discussion" section of the third issue of the 2016 *History of Medicine* journal was published the article "On the periodisation of the history of medicine" by Professor D.A. Balalykin. Considering this publication an invitation to discuss the issue, we decided to express our opinion regarding the periodisation of the history of medicine in the 17th-21st centuries.

D.A. Balalykin suggests dividing this time span of the history of medicine into two stages, or periods. The first is the stage from the 17th-19th centuries – "the period of the scientific revolution in medicine, which ultimately forms the system of ideas about medicine as a science" and is, basically, a "revision of all constituents of Galen's conception" [1, p. 253, 257–258] – and the stage from the 20th century to the present – the period of "modern scientific medicine," the most important distinctive feature of which is the decisive influence of technological and economic factors on the development of medicine [1, p. 257–258].

This view of the periodisation of the history of medicine in the Modern and Contemporary eras is undoubtedly legitimate. It can be regarded as an initial classification which, however, requires clarification. In order to accomplish that clarification, it is necessary to answer a number of questions. How was the scientific revolution occurring, and what was involved if it lasted more

Received: 13.12.2016

than two centuries? What were its main stages? Where is the line between the two stages of periodisation selected by D.A. Balalykin? What are the principal differences between them?

To answer these and other similar questions we need special tools that make it possible to recognise the stages in the development of scientific knowledge. Such tools were developed in the 1960s by the Western experts in philosophy and methodology of science (K. Popper, T. Kuhn, I. Lakatos, P. Feyerabend, S. Toulmin et al), as well as a galaxy of Russian philosophers and historians of science [2]. Their joint efforts refuted the classical positivistic notions of the growth of scientific knowledge as a linear process associated with the emergence of new theories through generalisation of continuously accumulating empirical data. New postpositivist approaches to the study of the problems of the historical development of science were established, and the concept of scientific revolutions as special stages in the development of scientific knowledge arose and was elaborated upon.

In our study of the history of medicine in the Modern and Contemporary eras we used one of those approaches, developed by Academician V.S. Stepin. In his philosophical and methodological conception of the structure and dynamics of scientific knowledge, scientific revolutions are considered special stages in the development of scientific knowledge associated with the restructuring of the research strategies set by the fundaments of science. The "fundaments of science" is a system of fundamental ideas, notions and principles of science which includes three main components: 1) the special scientific picture of the world (disciplinary ontology, a picture of the researched reality), which introduces a generalised image of this science in its main systemic and structural characteristics; 2) the ideals and norms of research (ideals and norms of description and explanation, evidentiality and justification, as well as ideals of structure and organisation of knowledge), which determine the generalised scheme of the method of scientific cognition; 3) the philosophical bases of science (understanding of a thing, process, space, time, causality, knowledge, theory, fact, method etc.), which substantiate the accepted picture of the world, as well as ideas and norms of science, owing to which the ideas of reality and methods of its cognition developed by science become included in the flow of cultural transmission.

There are two ways of restructuring the fundaments of science during periods of scientific revolutions. The first, described by T. Kuhn, is associated with anomalies and crises that occur under the pressure of new empirical and theoretical material appearing within scientific disciplines. The second is due to interdisciplinary interactions. In this case, various elements of disciplinary ontologies, ideals and norms, and philosophical fundaments are transferred from one branch of science to another. These kinds of "paradigmatic inoculations" lead to a reformulation of the old tasks of the scientific discipline, a formulation of new problems and the appearance of means for their solution. The restructuring of all the components of the fundaments of science corresponds to the global scientific revolution; transformation of only a special scientific picture of the world without any substantial changes to the ideals and norms of research and philosophical fundaments corresponds to the local one [2].

Having chosen this conception as a basis for analysing a substantial aggregate of historical medical data,[1] we established that during the period between the 17th and the 21st centuries there were not one, but at least five, disciplinary scientific revolutions, three of which were global, and the other two local.

The first one began in medicine in the 1620s and ended in the 1690s. It was a global disciplinary revolution and a revision of the

[1] The sources we used in our study could be divided into two groups. The first group includes the works of the foremost physicians and naturalists who made the greatest contributions to the development of medical science and practice; the second includes textbooks and manuals on medicine and individual medical disciplines used in medical schools. The sources of the first group made it possible to analyse the most significant discoveries, hypotheses and theoretical generalisations from the point of view of the notions existing at the time of their appearance, whilst the sources of the second group allowed analysis of the time when these discoveries and theoretical generalisations gained wide acceptance and inclusion within the flow of interdisciplinary knowledge transmission. The total number of sources we analysed is more than 350 domestic and foreign publications, making it impossible to list them all in this article.

picture of reality, ideals and norms of research activity and the philosophical fundaments of the erstwhile dominant system of representations of Graeco-Arab medicine. The transfer of fundamentally new ideas about the essence of scientific knowledge, formed at the turn of the 16th century owing to the works of J. Kepler and G. Galilei, served as its mechanism. The decisive role in that transfer was played by the studies of the English physician W. Harvey and the Dutch physician V. Plempius, which showed that the movement of blood in the human body and the physiology of sight can be explained without the notion of a reasonably functioning human soul, can be reduced to mechanical causes and can be clarified by purely spatial, quantitative conceptions. Largely relying upon the results of research by W. Harvey and V. Plempius, the great French philosopher and natural scientist R. Descartes revised the philosophical fundaments of medical science, putting forwards the ideas of mechanicism, and laid the foundations for a new picture of researched reality in medicine.

At the heart of the Cartesian picture of the world lay the notion of the mechanical motion of particles, which only possessed physical properties. The mechanical impact of one particle on another was seen as the only reason for any movement of a particle. The soul and body of man were deprived of common properties and counterposed, and the sphere of the former influence of the soul was limited only by thinking (consciousness) and will. The variety of numerous manifestations of life activity was deemed to be dependent upon the specific features of the anatomical structure of the human body. The body itself – the main subject of medical research – was regarded as a simple mechanical device that does not differ fundamentally from machines built by man. This view, in turn, opened unlimited possibilities for the development of medical problems employing experimental mathematical natural science.

The pivotal event that determined the recognition and reinforcement of the Cartesian picture of reality in medicine was the discovery of the lymphatic system by J. Pecquet, J. van Horn, O. Rudbeck and T. Bartholin between 1647 and 1652. The total revision of all information about the design and purpose of organs and parts of the human body that had been contained in canonical sources, which began in the middle of the 17th century, was both the expression and the proof of that recognition. The revision was carried out using a new scientific methodology, for which many new methods of conducting anatomical and physiological studies were developed and introduced. Methods such as microscoping, comparative anatomical studies, vivisections with thermometry, experiments with vacuum and artificial ventilation, injection with colourants and insufflation of blood vessels, drainage of glandular ducts and use of indicators to detect acids and alkalis proved to be the most effective. Astronomers, physicists and mathematicians (C. Wren, G. Borelli, R. Hooke, R. Boyle, G. de Roberval, A. Auzout, V. Viviani) took an active part in the research; they also showed great interest in understanding the structural organisation and mechanisms of the functioning of the human body as a purely mechanical device.

This joint activity resulted in a plethora of anatomical and physiological discoveries. The mechanical theories of urine formation, digestive glands' functioning, nutrition and tissue formation, respiration, reflex, hearing, vision, olfaction and touch were formulated and widely recognised, along with the theory of preformation for explaining the growth and development of animal organisms. Health was declared to be a state of unimpeded movement of particles constituting fluids and dense parts of the human body, and any disturbance of those movements with the formation of unhealthy matter was declared to be a disease. The diagnosis was reorientated to identify those disorders, and treatment, which became extremely aggressive, began to address the need for a swift recovery of the normal movement of particles using powerful stimulant, sudorific, spagiric agents and abundant bloodletting.

The successful functioning of the researched reality, based upon Descartes' kinetic mechanics, continued until the middle of the 1690s, when there developed a deep intra-disciplinary crisis in medicine, associated with the realisation of the impossibility of explaining all processes of life activity based solely upon the ideas of the 'collision' of particles deprived of any specific properties.

This crisis marked the beginning of the next scientific revolution in medicine, which lasted until the end of the 18th century. This revolution was of a local disciplinary nature and consisted of the formation of a new picture of the researched reality, which encompassed the revision of a number of Cartesian ideas proceeding from the idea that the human body, like other natural bodies, has its own sources of movement – "internal forces of action."

As applied to natural bodies in general, these notions were introduced into the European science of the Modern era by G. Leibniz and I. Newton. The inclusion of dynamic ideas in the picture of the researched reality in medicine began in the 1690s, continued until the first third of the 18th century and was largely attributed to four outstanding physicians and university professors – A. Pitcairn, F. Hoffmann, G. Baglivi and H. Boerhaave. They used the notion of 'internal forces of action' as a means of explaining those phenomena of life activity that were either inexplicable or poorly explained from the standpoint of Descartes's kinetic mechanics. The mechanisms of growth and development of the human body began to be associated with the action of "plastic (form-building) force" and blood circulation – with the "force of the heart" and "force of the beating veins." The notion of the "healing power of nature," which ensures spontaneous healing of wounds and recuperation, also gained recognition.

The human organism was no longer seen as a lifeless mechanical device, whose only difference from the machines created by man was the thinking soul. The gradual formation of ideas about the body as a mechanical hydraulic machine, the main life processes of which are controlled by the numerous vital forces given by God, had begun.

The pivotal event that determined the final rejection of the previous picture of the researched reality were the discoveries of A. Haller, who provided direct empirical evidence of the existence of forces intrinsic only to living organisms – irritability and sensitivity. Under the influence of his works, a new research programme was formed in medicine, within the framework of which not only forms and movements, but most importantly forces and specific properties, became the subject of study by physicians and naturalists.

Simultaneously with the development of studies aimed at studying the "active forces" and specific properties of organs and systems of the human body arose the first medical teachings (T. Bordet, P. Barthez, C. Hufeland, F. Medikus, J. Brown, J. Blumenbach, F. Mesmer) that described the vital activity of the human body in a healthy and sick state as a result of the combined action of various forces. The wide dissemination of these teachings in the second half of the 18th century marked the final consolidation in medicine of a new picture of the researched reality, not completely reducible to the mechanical.

A cardinal revision of the notion of a disease – which, mainly under the influence of T. Sydenham's works, attained the meaning of not so much internal damage as the response of "healing power" – was aimed at eliminating this disorder. Symptoms of diseases began to be considered as a result of the action of the force intrinsic to the whole body; they were declared independent from specific organs and parts of the body, in turn providing grounds for comparing individual nosological forms of diseases with independent living beings.

The emergence of a non-existent subject of medical study – individual diseases, embodied by independent natural entities – determined the need for fundamental changes in the diagnostic process. From then onwards, diseases, not patients, were considered the subject of medical examination. Diagnosis began to be based on the compilation of an accurate external portrait of the disease and the establishment of analogies to previously described nosological forms. Approaches to treatment began to be based on the notion that "the healing power of nature" is the thing that heals, and the doctor's task is to help it only in cases of extreme necessity, and with the greatest possible care.

Our studies have shown that the picture of the aforementioned researched reality functioned effectively until the 1790s, when the next local disciplinary scientific revolution, which lasted until the mid-1870s, began. Two successive "paradigmatic inoculations" from chemistry and biology served as its mechanism. The chemistry "inoculation" consisted of the transfer to medicine of A. Lavoisier's ideas that the elementary particles from which the

body is formed possess not only physical but also pronounced chemical properties, and vital activity is determined not by the play of vital forces, but by physico-chemical processes associated with the "slow burning" of nutrients consumed in food under the influence of oxygen. From biology to medicine were transferred the positions of the cellular theory, according to which all organs and parts of the human body without exception consist of cells or their derivatives, and the continuous progressive growth of living organisms is a consequence of the constant division of cells, and not the result of the action of "plastic force." These "paradigmatic inoculations" led to the emergence of new fields of scientific problems in medicine, the development of which led to the next revision of the researched picture of reality.

The new picture of reality introduced the idea of the human body as a steam engine, the functioning of which is determined solely by the exchange of substances and energy with the environment – the absorption of complex organic compounds created by plants and the transformation of the potential energy incorporated in them into the heat and mechanical work of their organs (A. Lavoisier, J. Liebig, J. Mayer, C. Ludwig, E. Brücke et al). It was believed that, like man-made analogues, the steam engine of the human body had a pre-determined, unchanging design, whose wear and tear was deemed insignificant and completely replenishable by protein. Health was defined as a state of the normal course of all physico-chemical processes of matter and energy exchange with the environment.

As a result of the successive efforts of M.Bichat, R. Laennec, J. Bouillaud, C. Rokitansky, R. Virchow et al, disease was now thought to be not an entity rioting within the body, but one of the life forms of the organism itself, consisting of the development of successive interconnected structural and functional changes in cells, tissues and organs as a result of physico-chemical influences of the environment, destructive for the body. Since in this case the object of diagnostic research was not abstract living beings, but actually actual patients and their bodies, there was a need for techniques and methods that would allow for detection of the structural and functional changes taking place in the body. Methods of physical (percussion, auscultation), instrumental (laryngoscope, ophthalmoscope, etc.), laboratorial (full blood count [FBC] and biochemical analysis of blood, urine) and functional (nasogastric intubation, thermometry, blood pressure measurement, determination of respiratory rate) diagnosis were developed and introduced.

In therapy, there arose an awareness of the need to abandon the "medicinal treasures" of antiquity. Owing to the joint efforts of chemists and physicians, an extensive medical reform was launched, which determined the appearance of the first drugs in the arsenal of physicians, which were pure chemicals with known pharmacological properties and scientifically based dosages and indications.

As shown by the results of our study, the next scientific revolution in medicine began between the 1870s and 1890s and lasted until the mid-20th century. Two "paradigmatic inoculations" from biology and a deep disciplinary crisis served as its mechanisms. The crisis was caused by the accumulation of a plethora of empirical facts, unaccountable from the standpoint of the aforementioned concepts of the body as a steam engine. The "inoculations" consisted of transferring the ideas of L. Pasteur's "inchoate" fermentation theory and C. Darwin's evolutionary theory to medicine, which opened new fields of scientific problems for medicine and revealed the inadequacy of existing views on the environment and the essence of its impact on the human body. The result of the joint influence of these mechanisms was the rejection of previous views of the human body as a mechanical device (simple system) and a radical revision of all the fundaments of medical science.

At the end of the 19th century, a new picture of the researched reality introduced the idea of the human body as an open equilibrial processual system reproducing its stable states as a result of interaction with the environment through mechanisms of self-regulation. Such a view of the human body in the form of a scientific hypothesis was expressed for the first time in 1878 by the distinguished French physiologist C. Bernard. However, it took more than 40 years and many discoveries in the field of studying integral systems of self-regulation (discovery of the immune and endocrine systems, discovery

of the autonomic nervous system, significant expansion of the notions of the regulatory capabilities of the central nervous system, etc.) to turn this hypothesis into a universally recognised natural science concept. The honour of creating such a concept, called homeostasis, belongs to the American physiologist W. Cannon. His theoretical generalisations proved so convincing that the concept of homeostasis in the 1930s-1940s gained worldwide recognition, which, in turn, marked the final consolidation in medicine of a new picture of the researched reality, based on the concept of the human body as an open equilibrial self-regulating system.

New ideas about the aetiology and nature of diseases have become the most important elements of this picture of reality. There was a clear realisation that the impact of any external factor is always refracted through the internal environment of the living body system, which actively transforms it in accordance with its internal relations. Consequently, disease was now seen not so much as structural damage, but as the complex response of the whole organism to changes in environmental conditions, a response which is compensatory-adaptive in nature and carried out with the help of integral systems of physiological self-regulation. This view led to renunciation of the idea of the existence in the body of isolated (local) pathological processes in favour of concepts of the disease as the "suffering" of the whole organism.

The adoption of new ideas about the causes and nature of illnesses had led to cardinal changes in the clinical thinking of physicians, approaches to diagnosis, and treatment of diseases. In diagnosis, the most important change was the rejection of the traditional 19th-century emphasis exclusively on the "clinical prediction of the pathoanatomical picture" in favour of a comprehensive assessment of the patient's condition, including a careful examination of all body systems, the patient's constitution, reactivity and nuances of the patient's inner experiences. The question of the obligation of individual psychological observation was raised and resolved.

Physiological, immunological, biochemical techniques, special apparatuses and methods for investigating functions began to be widely used as diagnostic tools. Methods based on the study of the limits of organ and systems' adaptability by evaluating the functional response to metered specific irritation became widespread. The greatest authority in the medical world was acquired by clinics endowed with modern equipment, which incorporated the departments of functional diagnostics and various diagnostic laboratories.

In general medicine, symptomatic therapy was replaced by etiotropic and pathogenetic treatment (hormones, vitamins, antibiotics, antipyretic and anti-inflammatory drugs, vaccines, sympatholytics and anticholinergics, sympatho- and cholinomimetics, preparations for sero- and chemotherapy), which was one of the most important achievements of the scientific revolution in medicine of the last quarter of the 19th to the first half of the 20th century. The means and methods of influencing the body as a whole, aimed at maintaining and strengthening systems of self-regulation, gained prevalence.

A true revolution occurred during this time in surgery. The widespread introduction of antiseptics allowed for the radical expansion and improvement in safety of surgical care; cavitary surgery came into existence. Later on, as the views on the nature of diseases were being revised, new directions for the development of surgery arose, the common distinctive feature of which was the gradual transition to organ-preserving operations with an emphasis on restoring impaired functions. Reconstructive, plastic and physiological surgery should be mentioned first amongst such directions. Anaesthesiology – which in the 1940s-1950s was separated into an independent discipline – and the development of theoretical bases and practical measures for the restoration and management of vital bodily functions, were rapidly developing.

The new view of the human body as an open equilibrial self-regulating system required a radical, critical rethinking of the erstwhile methodological approaches to cognition of the human body. Analytic methods of research (sectional, chemical analysis, acute physiological experiment) – which became traditional in the 17th and 19th centuries – were pushed into the background despite their continued active use. The leading method of cognition of life, which allows one not to think out the phenomena of life activity, but

to actually study them, was an experiment in which firstly, the living object (organism, cell) served as the object of experimentation, and secondly, in this living whole, its natural abilities for self-regulation of the basic life processes were maximally preserved. Thousands of new techniques and tools for research appeared in the arsenal of physicians (both in laboratories and in clinics) and constituted one of the most important achievements of the scientific revolution in medicine in the last quarter of the 19th to the first half of the 20th century. In the end, they determined the decisive influence of technological factors on the development of medicine, rightly marked by D.A. Balalykin, during this period.

The philosophical foundations of medicine also underwent a significant transformation. If in the former system of representations, things (bodies) acted as something primary, a substratum, and processes were interpreted as the impact of one thing (body) on another, in the new system of representations, any thing was seen as a processual system, self-reproducing as a result of interaction with the environment and self-regulation. The former classical determinism, supplemented by representations of cyclic and probabilistic causality, was affirmed by the notion that the whole is greater than the sum of its constituent parts and has special system properties that are irreducible to the properties of its constituent parts.

Thus, as a result of the scientific revolution of the last quarter of the 19th century and the first half of the 20th century, all the foundations of medical science were revised, and a new, non-classical type of scientific rationality was established in medicine, which in turn makes it possible to consider this as a global disciplinary revolution.

Starting from the middle of the 20th century and continuing to the present, the next global disciplinary scientific revolution is gradually unfolding in medicine. Its most important characteristic is the transition from the notion of research objects as self-regulating systems to the notions of them as non-equilibrial, historically developing systems for which self-regulating systems appear only as one of the states of the dynamics of a historical object, a sui generis section, a stable stage of its evolution.

An emphasis on the study of complex historically developing systems substantially restores the ideals and norms of research activity. The historicity of the systemic complex object and the variability of its behaviour presuppose a wide application of special methods of describing and predicting its states – the construction of scenarios of possible lines of system development in bifurcation points. Theoretical descriptions based upon the approximation method – theoretical schemes using computer programs, etc.– are increasingly competing with the ideal of the theory structure as an axiomatic-deductive system. In the natural sciences and medicine, the ideal of historical reconstruction, which is a special kind of theoretical knowledge previously used primarily in the humanities, is being introduced increasingly.

In the philosophical foundations of science there are arising new understandings of the categories of space and time (recording of the historical time of the system, hierarchy of space-time forms), the categories of possibility and reality (the idea of a set of potentially possible development lines in bifurcation points), the categories of determination (objective causality, notions of the role of history in the selective response of the system to external influences), etc.

The mechanisms of this revolution were the disciplinary crisis and the "paradigm inoculation" of the concepts and approaches of interdisciplinary nonlinear science (often called synergetics) – the theory of dynamical chaos, theory of self-organisation, bifurcations and catastrophes and fractal geometry.

The disciplinary crisis was the result of an active accumulation of factual material, inexplicable within the framework of ideas about the human body and its environment as self-regulating systems. Most of these data were obtained by experimental study of the functioning of the central nervous system, fine coordination of motor functions, complex forms of behaviour and creativity. Attempts to resolve this crisis led to the development and implementation in the public consciousness of individual theoretical concepts that included elements of the post-nonclassical vision of the human body as a non-equilibrial, historically self-developing system. In physiology, A.A. Ukhtomsky's theory of dominant, N.A. Bernstein's physiology of

motor activity and P.K. Anokhin's theory of functional systems became such concepts. Despite a number of individual differences, all three of those concepts were unified in their main principles. They viewed the organism as a complex, open, historically developing system whose functioning is associated with the ongoing internal processes of self-organisation of expedient spatio-temporal functional structures that possess the ability to accumulate and use past experience.

In pathology, a fundamentally new view of the causes and nature of disease was expressed by I.V. Davydovsky, who justified the need to study pathological processes on the basis of historical, evolutionary-biological and systemic approaches; and G.N. Kryzhanovskiy, who developed the doctrine of pathological functional systems. In epidemiology, V.D. Belyakov's theory – which considered the epidemic process as the result of self-organisation, self-development and self-regulation of a multi-level parasitic system – and B.L. Cherassky's socio-ecological concept of the epidemic process became such concepts.

The "paradigmatic inoculation" of the ideas and approaches of interdisciplinary nonlinear science in medicine began in the 1970s-1990s. The main role in its implementation was played by American scientists – L. Glass, M. Mackey, E. Goldberger, D. Rigney, B. West and others. Scientists' widespread use of the notions and mathematical tools of nonlinear science for the study of the human body led to two major discoveries. Firstly, it was proved that all the physiological rhythms of the human body have signs of dynamical (deterministic) chaos – random aperiodicity, the emergence of order and the existence of strange attractors. Simultaneously were obtained numerous factual confirmations of the fact that under different pathological conditions, there is a clearly expressed periodicity in physiological rhythms, accompanied by a loss of variability (dynamic diseases). Secondly, during the quantitative analysis of the branching of the respiratory tract and a number of other structural formations of the human body (heart, intestine, vascular and lymphatic systems, neurons, etc.), they were found to be fractal-like structures that represent a trace of chaotic nonlinear dynamic processes.

These discoveries allowed scientists to make a truly revolutionary conclusion – that the human body, from strange attractors in the heart rhythm to the fractal dimension of the lungs, is not a homeostatic but a nonlinear system that is in a state of dynamical (deterministic) chaos.

A new research programme, associated with the development of problems of fractal physiology, emerged and was widely accepted. At the end of the 20th century and the beginning of the 21st, the field of application of the notions and methods of nonlinear science in medicine was significantly expanded owing to the inclusion of epidemic processes and problems of public health and health service. In epidemiology, the mathematical tools of nonlinear science were being widely used to predict the occurrence of epidemics by identifying a chaotic attractor in the spread of diseases. In domestic and occidental public health service, the view of national health systems as nonlinear, self-organising and self-developing in the conditions of close interaction with dynamically developing political, economic, social and ecological subsystems of Western societies, was formed and received recognition.

Practical implementation of the synergetic approach to the study of the human body in normal and pathological conditions allowed researchers to offer new methods of solving many urgent medical problems of general pathology, neuroscience, clinical psychology and psychiatry. Fundamentally new methods for assessing the dynamic state of an individual human organism were developed, creating conditions for the introduction of personalised medicine and a gradual refusal to work with averaged statistical indicators. The exact methods of the natural science study of the mechanisms of influence of the entire existing variety of medical technologies on the human organism – from the newest armamentarium, pharmaceuticals, cellular and nanotechnologies, to traditional methods of restorative medicine, non-drug therapy and eastern practices, which in turn opened up prospects for the integration of modern natural and oriental medicine – were introduced.

It is impossible to fully treat the topic of scientific revolutions in medicine during the period between the 17th and 21st centuries, or

to present the entire system of evidence that we have gathered for their existence in one journal article. A monograph and a series of articles was devoted to the detailed analysis of this problem [5–7]. However, even the results of our historical reconstruction of the dynamics of the development of modern natural medicine presented in this publication allow us to state that, during the period between the 17th and the 21st centuries, there were at least five cardinal changes in the dominant systems of ideas about the subject field of medicine. It should be emphasised that not only individual facts or theories were subjected to changes, but also the whole set of views on the fundamental principles of the vital activity of the organism and on the causes and nature of diseases, approaches to diagnosis and treatment of human diseases. The latter, in turn, allows us not only to identify the existence of five scientific revolutions in medicine of the Modern and Contemporary eras, but also to distinguish five independent stages in the history of the development of modern natural medicine, each of which corresponds to one of the five scientific revolutions that occurred during that period.

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