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What do we know about Erasistratus? Part 1

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The work of renowned 3rd century BC Alexandrian doctor Erasistratus is significant in the history of ancient medicine. The author of the article calls into question numerous assessments of his work, which have evolved in domestic and foreign historiography. The article summarizes Erasistratus' views on medical theory and practice, using supporting sources. The author comes to the conclusion that the natural philosophical views of Erasistratus, unlike generally accepted views, were far from the teachings of the peripatetics, and suggests that the clinical practice of Erasistratus be considered as the basis for the future development of the teaching of the school of methodologists.

The works of Galen are an important source of information about Erasistratus. Using a comprehensive analysis of these sources, a definite idea can be formed of the approaches of Erasistratus and his later followers to solutions for practical clinical problems. By comparing known data, it is possible to carry out a historically reliable reconstruction of the doctrine of Erasistratus. New sources introduced into Russian-language scientific discourse allow us to determine the continuity of the views of Chrysippus of Cnidus and Erasistratus. This, in a broader context, raises the question of the influence of atomistic natural philosophy on the medicine of antiquity in the 4th and 3rd centuries BC. The principal rejection of venotomy, the tactics of using pressure dressings and the patient's fasting as a means of combating the plethora were the key moments of the clinical tactics not only of Erasistratus, but of generations of members of certain ancient medical schools. This allows us to conclude that Herophilos and Erasistratus did not adhere to similar views on the theory and practice of medicine. It can be assumed that completely different fields of medical scientific thought were developed in Alexandria in the 3rd century BC.

Keywords: *history of medicine, ancient medicine, Erasistratus, methodologists-physicians*

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Erasistratus, along with his contemporary and compatriot, Herophilus, is a legendary figure in the history of medicine. Stories about the excellent state of medicine in Alexandria in the 4th century BC are found in almost all review monographs and textbooks on the history of medicine from recent decades. The Alexandrian "medicine of Herophilus and Erasistratus" historians of antiquity also often cited as an example of the heyday of the science and culture of the Hellenistic period. Herophilus and Erasistratus are considered outstanding physicians who made enormous contributions to the development of medicine. The main achievements of Herophilus are generally thought to be connected with the study of anatomy, and those of Erasistratus to be connected with the creation of experimental physical models for the study of physiological processes [1–4]. In the specialized literature there are also parallels between Erasistratus and the outstanding mechanic and mathematician Archimedes. The tendency to refer to Herophilus and Erasistratus without mentioning their names, as if emphasizing their overall contribution to the development of medicine, has been preserved in historiography. For example, J. Longrigg calls these doctors "two great Alexandrian anatomists" [5, p. 61]. He also points out that until the end of

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the 1980s, "notwithstanding the brilliance of the achievements of these two Alexandrians, no fully comprehensive editions of their fragments were available to scholars" [5, p. 183]. Serious work with sources in this area comprised, according to J. Longrigg, collections in German containing fragments of texts by Herophilus and Erasistratus, prepared by K.F.H. Marx and R. Fuchs [6, 7]. He references two articles in English on the same topic by J.F. Dobson [8, 9]. A significant amount of information about the work of the famous Alexandrian scientists was obtained only in the late 1980s and early 1990s: I. Garofalo's edition and the fundamental work of H. von Staden were foremost.[1]

Sources translated into Russian in recent years within publications of Galen's "Works" [12–15] testify to the significant differences in the views of Erasistratus and Herophilus on medical theory and practice. Carefully considering each, even insignificant, reference to Erasistratus in the works of Galen, it is possible to reliably reconstruct, step by step, the views of the famous Alexandrian doctor.

J. Longrigg believes that the most important source of information about Herophilus and Erasistratus is the works of Galen. In his opinion, "Galen was both well acquainted with their works and patently influenced by them, although at times his admiration is replaced by severe attack" [5, p. 183]. Such a generalization seems excessive: in the accessible texts of Galen, I did not encounter much criticism of Herophilus, nor admiration for the works of Erasistratus. Galen writes little about Herophilus and, as a rule, quite dryly: he acknowledges the moments when Herophilus is right or when his works are verified by scientific discovery. However, J. Longrigg rightly notes that Galen is hostile to Erasistratus, who, in his opinion, "had ill-advisedly rejected such traditional Hippocratic beliefs and practices as the theory of the four humours and phlebotomy" [5, p. 183]. This is true, but in the works of Galen there are many fragments in which he concedes to the correctness of Erasistratus in these or other matters.

Since the 1920s, descriptions of experiments have appeared in the specialized literature that attempt to model the physiological processes that Erasistratus allegedly reproduced using physical instruments. The founders of this tradition can be considered T. Meyer-Steineg and K. Sudhoff. For a long time their "History of Medicine" [1] was practically the only comprehensive study of the history of medicine translated into Russian, and the influence of their judgments on Soviet scientists was especially significant. The contribution of these researchers to the development of the history of medicine was greatly appreciated in English historiography, and it is not surprising that generations of Russian scientists reproduced their point of view without much criticism.

However, the descriptions given by K. Sudhoff and his co-author are rather vague and unspecific: the authors speculate on various views of Erasistratus but rarely refer to other sources. For example, they indicate that, according to Erasistratus, disease is a state in which the natural functions of the body are not carried out due to the overfilling of parts of the body with the insufficiently digested remains of food. In T. Meyer-Steineg and K. Sudhoff's opinion, Erasistratus calls this condition "plethora", and it is at the center of his theory of pathology. They indicate that Erasistratus was the first to describe the chain of pathological changes of various organs – for example, dropsy of the liver – and argue that Erasistratus made these observations during autopsy. They believe that these and other pathoanatomical studies led to Erasistratus' exaggeration of the meaning of "purely local changes" [1, p. 81] in general pathology. The question immediately arises: how can dropsy and liver changes that are observed be interpreted as an overflow with undigested parts of food? After all, "plethora" is a very common ancient Greek medical term; since the time of Hippocrates it has meant a fluid overflow. T. Meyer-Steineg and K. Sudhoff also indicate that Erasistratus considered fever a symptom (not a disease) and a consequence of blockage of air circulation in the large arteries that resulted from the penetration of blood from overcrowded veins. However, there is no reason to doubt that Erasistratus viewed the liver as a hematopoietic organ in which blood was formed from food that entered the body. This view was formulated by Plato in "Timaeus", although the idea appeared earlier. A similar understanding of the principle

[1] J. Longrigg noted two works [10], [11]. See [5, p. 184].

of hematopoiesis, which developed in the Kos and Knidos traditions in the 5th century BC, is also found in the texts of the Hippocratic Corpus. T. Meyer-Steineg and K. Sudhoff do not explain how the thesis of undigested food correlates with Erasistratus' view on the genesis of fever that they describe. I note that their interpretation of the views of Erasistratus on the flow of blood in the arteries from the crowded veins is correct and is confirmed by the corresponding excerpts from the texts of Galen. It is also true that Erasistratus explains the local inflammatory process by the flow at the level of smaller vessels – for example, researchers note that, according to Erasistratus, "arthritis occurs due to the plethora of joints" [1, p. 81]. This statement is true, but it does not agree with the statement about the body parts overfilling with "undigested food remains" because "plethora" is a fluid overflow. For example, the "plethora" which leads to inflammation is the release of excess blood volume beyond the venous bed. In order for this to happen, the food must be converted into blood, and in excess. How does this relate to the thesis of the body parts overfilling with undigested food remnants? K. Sudhoff and his co-author state: "Reducing all diseases to one principle, 'plethora', Erasistratus in his constructions could completely abandon the elucidation of etiology in the proper sense of the word, since the deep causes of 'plethora' had only theoretical significance for him" [1, p. 81].

However, the opposite is further asserted: "In accordance with his theoretical premises, Erasistratus built his therapy on two basic principles. Therapy must first of all have an etiological character, i.e. should be directed against a common cause, against the 'plethora'; on the other hand, it must be of a local character, i.e. the object of its direct impact must be a sick organ" [1, p. 82]. So did Erasistratus deny the etiology of the disease or, conversely, claim the etiological principle?

T. Meyer-Steineg and K. Sudhoff are correct about certain of Erasistratus' judgments. They rightly point out that in his therapeutic tactics, measures aimed at "eliminating the body overflow" – diet (even complete abstinence from eating) and the use of laxatives, emetics, diuretics and diaphoretic drugs – were of key importance. At the same time, they acknowledge: "Erasistratus resorted to bloodletting only in rare cases, since, by extracting a little blood, we remove a few harmful substances; while extracting a sufficient quantity of it, we remove more than it is necessary in the interests of the patient" [1, p. 82]. However, this statement is incorrect: Galen says that none of the works of Erasistratus recommends venotomy.

One of the main issues in the history of Alexandrian medicine of the 3rd century BC, which was central for medical historians in the second half of the 20th century, was the fact that vivisections were carried out in Mouseion at Alexandria. The preserved sources (mainly the evidence of Aulus Cornelius Celsus and Tertullian) were interpreted in different ways. This question seems to me of secondary importance, since such vivisection could not have any practical purpose. It is possible that the penitential system of the Ptolemaic state (as well as many states before, after and during their reign) understood any actions to be justified in relation to especially dangerous criminals. This attitude is evidenced by the sophisticated torture and execution practices known to historians. However, even if vivisection took place, they were sporadic. The person being tortured would resist, and even if he were immobilized (for example, stretched with straps and rigidly fixed), natural physiological reactions would occur (for example, convulsions, heavy bleeding). The information that a doctor can receive from such a procedure is inherently insignificant. Even if Herophilus or Erasistratus once agreed to examine a living criminal, they could soon see that the autopsy of a recently deceased person gives much more information than an uncomfortable and in all respects unpleasant vivisection. Attention should also be paid to the stubborn denial by the overwhelming majority of ancient doctors of the fact that the arteries contain blood. We know of only two famous doctors of antiquity who maintained that the arteries contain blood and pneuma – Herophilus and Galen. The sources available to us indicate that Erasistratus and many others (before and after him) believed that the arteries contain only pneuma. This belief is the basis of Erasistratus' thesis about the inflammatory process as a pathology explained by abnormal overflow of excess venous blood into the arterial bed or surrounding tissue vessels. If Erasistratus had dissected a living person, he would have been convinced that the main arterial vessels contain

blood. The generally accepted opinion of ancient doctors that arteries contain only pneuma suggests that surgical interventions for many hundreds of years were of a local nature. This is indicated by the works of Galen, which trace the continuity of the surgical and traumatological practices of the author in relation to the Hippocratic Corpus. This is all the more important to understand, since we know that Galen was a very skilled surgeon-experimenter, who carried out the most complex operations and physiological experiments on animals.

An attractive argument in favor of the possibility of carrying out vivisection is the thesis of the fundamental difference between a living and a dead body. The denial of the cognitive significance of the anatomical research by empiric physicians, conceived in the spirit of Stoic philosophy, was based on this idea. If with the onset of death the human body loses something which defines it, then the knowledge obtained from the study of the corpse cannot be extrapolated to a living organism. Therefore, anatomical autopsy is meaningless, since it does not provide information about a living organism.

Even if any of the Alexandrian physicians attempted to dissect a living person, he would have encountered these problems and become convinced vivisections meaningless in terms of the possibility of obtaining useful knowledge.

Thus, according to the historiography, a complimentary judgment was formed on the significance of the works of Erasistratus as a doctor, anatomist and physiologist, but there are no sources that support this point of view. Moreover, the famous works of Galen make us doubt the correctness of such an evaluation of Erasistratus' works. The texts of Galen as a source of information about the work of Erasistratus should, of course, be accepted with caution. But that is the way to treat any source. Criticism of sources is one of the main research methods that any historian must possess.

To properly understand the information about the views of Erasistratus that Galen reports, it should be borne in mind that for Galen he is a negative historical figure. Evidently, the approaches of methodologists contemporary to Galen had much in common with the teachings of Erasistratus about diseases and methods of treatment. Galen often criticizes the famous Alexandrian physician, never tiring of emphasizing the continuity of 2nd-century methodologists' approaches in relation to the ideas and practice of Erasistratus. Many years of experience with the texts of Galen allows me to argue that some of his reasoning is openly biased, speculative and extremely emotional. Even the possibility of being convicted of bias cannot stop him. A vivid example is the reasoning of the great Roman physician about Plato's views on medicine in the treatise "The Doctrines of Hippocrates and Plato" [14, 15].

It should be clearly understood that Galen was a conscientious scientist. His compliments towards the authors with whom he sympathizes, of course, are based on his conviction in the scientific truth of their judgments. As a doctor, he was scrupulously attentive to his patients, and the final clinical result was for him the main way to verify scientific fact. Galen always argues his point of view and analyzes the judgments of his opponents in detail. All these factors give the scientist-historian the opportunity to choose the correct methodology for a critical analysis of the great Roman physician's assessments of the views of Erasistratus.

In a number of his works, in addition to criticizing Erasistratus, Galen states his obvious achievements and correct judgments on various aspects of medical theory and practice. In my opinion, these estimates should be trusted. If Galen praises Erasistratus for something, then, given his general negative attitude towards the heritage of this famous Alexandrian doctor, such achievements should have been obvious and indisputable. Positive assessments of individual judgments of Erasistratus by Galen are forced: he seems to force himself to express them and immediately adds a fair amount of criticism.

We should proceed from the fact that Galen was well acquainted with the works of Erasistratus: in the 2nd century they were widely distributed and known to specialists. Doctor-methodologists made up the majority of the medical elite of the time, and for them Erasistratus was a respected scientist whose work influenced their professional views. It is hard to imagine that Galen could afford to deliberately distort the views of Erasistratus without risking being accused of dishonesty. Galen accurately reproduces the views of Erasistratus, constantly referring to his works, so Galen's two

works – "Bloodletting, against the Erasistrateans at Rome" [12, pp. 426–462] and "Bloodletting, against Erasistratus" [16][2] – are of great value: they made known some of the main works of Erasistratus and made it possible to comprehend the range of his professional interests and the main issues of medical theory and practice that interested him. The following works were written by Erasistratus: "On Bleeding", "On Fevers", "On Wounds", "On Stomach Diseases", "On Gout", "On Health", "On the Abdominal Cavity", "On Paralysis".

In the treatise "The Doctrines of Hippocrates and Plato", Galen, referring to Erasistratus' essay "On Fevers",[3] states that the great Alexandrian established the existence of structures that we now call heart valves. Galen points to the "membranes" that are attached to the mouths of the vessels, through which blood flows to the heart and away from it. At the mouth of the hollow vein, Erasistratus describes three membranes, the arrangement of which resembles the axis of the arrow, and calls them tricuspid. Valve structures are described by Erasistratus in relation to the mouth of the pulmonary arteries (Galen calls them "venovenous arteries"). J. Longrigg notes that these membranes, according to Erasistratus, play an important role in the overall work of the heart, "changing" at the appropriate moments: "those which adhere to the vessels which lead matter into the heart from the outside, are tripped by the entrance of the material and, falling back into the cavities of the heart, by opening their mouths, give an unimpeded passage to what is being drawn into their cavity. For, he says, material does not rush in spontaneously, as into some inanimate vessel; but the heart itself, dilating like a coppersmith's bellows, draws the material in, filling itself in diastole. Membranes, which, he said, lie on the vessels that lead material out of the heart, are considered by Erasistratus to behave in the opposite way. For they incline outwards from within and, being tripped by the material passing out, open their mouths in proportion to the amount of the material furnished by the heart. But for all the rest of the time they firmly close their mouths and do not allow any of the material which has been emitted to return. So, too, the membranes upon the vessels which lead material into the heart close their mouths whenever the heart contracts and do not permit any of the material drawn in by it to flow back again to the outside" [5, p. 206]. Further, J. Longrigg summarizes: "Erasistratus was probably the first person to discover the coordinated function of all four main valves of the heart. It has been suggested that it was he who actually discovered and named the tricuspid and bicuspid valves. But while he may have indeed discovered them, it should be noted that Galen here specifically attributes the introduction of the former term to 'some of the Erasistrateans'. It is evident from the above account that the Alexandrian had a clear knowledge both of their form and function and regarded them correctly as mechanisms for maintaining the flow in one direction. The tricuspid valve at the entrance to the right ventricle allows the blood to enter it, but not to relapse into the right auricle and vena cava, while a second semi-lunar valve (the pulmonary valve) at the base of the 'arterylike vein' (i.e. the pulmonary artery) allows blood to flow out towards the lungs, but not back into the heart. Similarly, two valves, the bicuspid (i.e. mitral) and the semi-lunar (aortic), control the flow into and out of the left side of the heart, though in this case, according to Erasistratus, it is *pneuma* that enters and leaves" [5, p. 207].

This description of Erasistratus' of the rhythmic work of the heart allowed some medical historians to assert that the Alexandrian doctors considered the work of the heart as the work of a kind of double pump. For example, I.M. Lonie points out that Erasistratus could observe how a pump with two alternating sets of valves works [17]. In a later treatise, "Pneumatica", Hero of Alexandria mentions a similar pump, invented by Ctesibius, a contemporary of Erasistratus.[4] The historiography contains many versions of Erasistratus' notions about the physiology of the heart as the work of a pump – the problem lies in the fact that they are all created by scientists and not confirmed by sources. We have not a single fragment from the works of Erasistratus indicating the viability of such comparisons; therefore all the

[2] In Russian, the quotations of Galen's treatise "Bloodletting, against Erasistratus" are given in the translation of Z.A. Barzah.

[3] See the 6th book of Galen "The Doctrines of Hippocrates and Plato" [15, p. 197]

[4] See [5, p. 208].

arguments that he was the scientist who created the mechanical models of physiological processes are unfounded.

What did Erasistratus really know and what was erroneous? He certainly conceived of the function of the pulmonary artery and the importance of the heart for the movement of blood. Erasistratus correctly described the structure of the brain, as indicated by Galen: "7.3.8. He [Erasistratus] writes as follows: 'We viewed also the structure of the cerebrum, and it was bipartite, as in the other animals, and there were ventricles lying there, elongated in form. The ventricles were united by a perforation at the point of contact of the parts. From this point a passage led to the so-called cerebellum, where there was another small ventricle.

7.3.9. Each of the parts had been partitioned off by the meninges. For the cerebellum had been partitioned off by itself, and also the cerebrum, which is similar to the jejunum and has many folds; and the cerebellum, even more than the cerebrum, was provided with many varied convolutions.

7.3.10. So the observer learns from these that as it is in the other animals – deer, hare and any other that far excels the rest in running being well provided with the muscles and sinews useful for this activity –, so in man, since he is far superior to the other animals in thinking, this (member) is large and has many folds. And the outgrowths of the nerves were all from the brain; and by and large the brain appears to be the source of the nerves in the body'" [15, pp. 266–267].

In other words, Erasistratus distinguishes between the brain and the cerebellum and isolates the ventricles of the brain, although it was initially believed that all the nerves originate from the "*dura mater*". Galen reports the following: "7.3.6. Erasistratus, who for a long time saw only the outer part of the nerve, (the part) that comes from the *dura mater*, thought that the whole nerve grows from that source, and most of his writings are full of statements that the nerves grow from the meninx that encloses the brain <...> 7.3.32. Another passage, which is single and unpaired, empties into the first beginning of the spinal medulla; and here especially, when the dura mater is cut at this point, the entire passage is laid bare, along with the end of the posterior ventricle of the brain. This was not the least reason why Erasistratus mistakenly believed that the animal immediately becomes motionless when the meninx is cut; for he saw that oxen wounded at the first vertebra become motionless as soon as the meninx is severed" [15, p. 270].

At the end of his life, thanks to the experience gained from anatomical autopsy, Erasistratus reached the conclusion that the nerves come directly from the brain: "However, when in old age, having retired and devoting all his time to scientific research, he began to more skillfully do autopsy, the results of these experiments led him to the idea that the core of nerves is growing from the brain" [15, p. 266].

Of course, Erasistratus' views on pneuma in no way contradict his thesis that the nerves come from the brain. Judging by the remarks of Galen, Erasistratus believed that from the brain also departs pneuma and, spreading inside the nerves, transmits the signal from the brain to different parts of the body.

H. Diels points out that a corpuscular theory, proposed earlier by Peripatetic Strato from Lampsacus [18], is described in the preface to the "Pneumatica" of Hero of Alexandria. According to the famous German historian and philosopher, both Hero and Erasistratus believed that matter consists of tiny particles alternating with emptiness, and nearly all parts of the body contain gaps (but not "great emptiness"). Accordingly, if somewhere there is a void greater than normal, then the surrounding substance immediately penetrates, filling it. H. Diels addresses this theory, referring to Simplicius, who, in turn, attributes it to Strato. H. Diels himself, continuing this thought, points to the connection of Erasistratus with the traditions of Lyceum. However, Diogenes Laërtius in the essay on Theophrastus only notes that Erasistratus could have attended Theophrastus' lectures in Lyceum.[5] In other words, there is no evidence that Erasistratus was in Lyceum. Erasistratus lived for some time in Athens, but he could likewise visit the philosophers of other schools and, as Laërtius remarked, "could listen to the lectures of Theophrastus".

J. Longrigg addresses the combination of the Stratonic "corpuscular theory with the theory

[5] Diogenes Laërtius: "Some say that the doctor Erasistratus was also his listener and this is quite plausible" [19, p. 222].

of pneumatic", referring to the description of one of the experiments of Erasistratus cited by Anonymus Londinensis.[6] The Alexandrian physician recommends weighing a bird or a similar living thing, leaving it for a while without food in a closed vessel, and then weighing it again with all its excrement. Erasistratus points out that the total weight after the animal has stayed in the enclosed space will be less than the animal's weight before it was placed in the vessel. The loss of weight in excess of the weight of the excrement, in his opinion, indicates that the animal emits certain emanations into the atmosphere – an invisible substance that, in its body, has a real weight. J. Longrigg also argues that Erasistratus was very keen on such mechanistic ideas [5, p. 215]. This is evident from the peculiarities of his views on the digestion of food. Here, Erasistratus rejects the Hippocratic tradition, which asserts qualitative changes in food in the stomach under the influence of internal heat. Erasistratus considers the main process in digestion to be the mechanical effect of the stomach muscles. It is under their influence that the food mass is processed into a fairly homogeneous nutrient and then squeezed out as a lacteal juice through the walls of the stomach and intestine into the blood vessels. Through them this juice is transferred to the liver, where it is converted into blood. During this process, the contents are separated from the bile and enter the gallbladder, and the pure blood from the liver enters the hollow vein. Actually, according to the same logic, as a result of mechanical extrusion of excess blood mass from the venous bed at the level of small vessels, an inflammatory process occurs. Galen does not object to Erasistratus' thesis about the importance of the role of "plethora" in the local pathological process, but the fact that the Alexandrian doctor denies the importance of internal heat Galen certainly does not like.

Erasistratus proceeds to assert that there are different types of endogenous pneuma: "Psychic (pneuma) starts from the head, and vital pneuma from the heart" [14, p. 284]. However, there is no solid ground to assert that, unlike Galen, he had a definite opinion on the functions of these pneuma species in the general organization of the vital activity of the organism. Nevertheless, it is obvious that Erasistratus distinguishes between pneuma species by origin.

Erasistratus denies the Koss tradition that assigns the tetrad of essences (cold, hot, wet, dry) primary importance in pathogenesis. Diogenes Laërtius, as already stated, mentions that Erasistratus may have been a pupil of Theophrastus. On this basis, Erasistratus began to be thought a peripatetic. H. Diels speaks of the corpuscular theory of the peripatetic Strato of Alexandria (the disciple of Theophrastus) as the basis of Erasistratus' natural philosophical views. There are no good reasons to dispute this opinion: sources to the contrary are lacking. However, I note that there is also no clear indication of such a link in the sources available to us. We know for a certainty that Erasistratus taught about invisible corpuscles and their emanations emitted by living bodies (as evidenced by the experiment with the bird described by Anonymus Londinensis). Can we assume that Erasistratus was inclined to atomistic views? After all, his alleged sympathy for Strato's ideas is a mere assumption designed to reconcile two preliminarily known theses – the corpuscular nature of matter and the training in Lyceum. But the latter did not prevent Erasistratus from denying the fundamental peripatetic doctrine of the tetrad of essences!

In historiography, it is common to mention Erasistratus' judgments about emptiness in a material object. Galen confirms them: "If something becomes depleted, that which is next to it fills up the void left. Erasistratus normally calls this phenomenon 'filling in proportion to emptying'".[7] However, in this opinion one can recognize not only Aristotelian Nature, which "does not tolerate emptiness", but also the filling of atomic particles. Indeed, in Democritus and especially in Epicurus, the accurate concept of emptiness is an important part of the theory.

Erasistratus does not share Plato's opinion on the nature of breathing: "The philosophy of Plato differs from the philosophy of Hestiaeus from the Academy, as well as the views of Erasistratus, who claimed that air moves along a perfect circly and always returns to the same point in the same manner. <...> Breathing cannot be an action or movement through a "circular

[6] See [20] about Anonymus Londinensis and his work.

[7] See Galen's treatise "Commentary on Plato's 'Timaeus'" [13, p. 778].

impulse", Erasistratus proved that, refuting Hestiaeus' claims" [13, pp. 779, 781]. The famous Alexandrian doctor, according to Galen, taught incorrectly about the liver, believing that the purpose of the branching veins in the liver was to separate yellow bile.[8]

Still more differences appear between the views of Galen and Erasistratus on the function of the kidneys. It is important to understand that Galen's works by no means represent an endless list of a particular scientist's brilliant insights, but to a large extent summarize the theory and practice of more than five hundred years of the development of the school of Hippocratic rationalists. Without a doubt, Galen was a brilliant thinker whose name is associated with a number of important scientific achievements. However, his own contribution, for example, to the development of surgery or obstetrics and gynecology is small. Moreover, V. Nutton rightly draws attention to Galen's desire to exalt himself, sometimes ignoring other people's priorities.[9] For example, Galen repeatedly mentions Marinus as an outstanding anatomist who "after the ancients revived anatomical study which had meanwhile fallen into neglect".[10] However, how often does Galen refer to Marinus or Rufus of Ephesus when presenting his views on the structure of the human body? Such references are rare! That is why I focus on the significance of Galen's works as a sum of the creativity of many apologists of the Hippocratic tradition – from this position the objections of Galen to Erasistratus and his followers are especially important. For Galen, the kidneys are part of the secretion system, and therefore the circulation of the kidneys becomes especially important. However, Erasistratus teaches that there is no blood in the arteries, but only pneuma: "Neither Erasistratus nor any other, who believed that arteries contained only air, was able to explain the usefulness of those arteries in the kidneys. After all, if it only veins that clean kidneys, and which is why, despite their small size, there are considerable veins penetrating into the kidneys, there would have not been the same number of arteries as veins, and perhaps there would have been no need at all for arteries in the kidneys, unless they were very small and inconspicuous, like nerves" [21, p. 202].

In Galen's opinion, Erasistratus and his followers do not fully understand the significance of the teleological principle, and therefore "they are incessantly praising it [nature – D.B.] because it did nothing in vain, but in reality they are not pursuing this goal and they are not trying to prove that this praise is indeed justified for each organ; quite the opposite, they are willingly silent and omitting much about the structure of the parts" [21, p. 202].

Galen evaluates Erasistratus' explanation of the spleen thus: "It was created without any purpose with some superfluous wisdom. And he [Erasistratus – D.B.] is not ashamed to maintain that nature, which does nothing irrational, – that is his own expression – created such a large organ which is completely useless. Out of concern, apparently, that it had deliberately forgotten about its art, nature, by creating on the right side the liver of an animal still in the womb, counterposed it on the left side, wishing to create something in that area as well" [21, p. 184].

The views of Erasistratus on the structure and function of the vascular system are quite complex. Erasistratus (as well as many other doctors of antiquity) believed that the arteries in the normal state contain only pneuma. On the other hand, it is generally accepted that Erasistratus carried out serious anatomical studies. It is impossible to imagine that a doctor with such a reputation and such an abundance of diverse patients never used a scalpel and did not encounter serious penetrating wounds. Consequently, he could not help but observe the bleeding from the arteries.

Galen gives insight into Erasistratus' views: "If you cut several main arteries at the same time, blood flows from them – almost everyone agrees on that. Therefore, those who completely reject the existence of blood in the arteries, like Erasistratus, nonetheless agree that arteries merge with veins" [21, p. 248]. This explains the inflammatory process: "Erasistratus himself diligently teaches us that inflammation occurs only as a result of blood pouring out of veins into arteries" [21, p. 248]. This is a logical explanation, combined with the idea of completely filling the arteries with a pneumatic: "If arteries expand similar to bellows

[8] See Galen. "The Function of the Parts of the Body" [21, p. 180].

[9] See [2].

[10] See the 8th book of the treatise "The Doctrines of Hippocrates and Plato" [15, p. 34]

not because they are filling up, but are filling up because they are blown like the blacksmith's bellows, they must suck some particles from the veins, because even Erasistratus himself accepts the existence of anastomoses between veins and arteries" [21, p. 255]. Galen disagrees. For him, as for Herophilos, it is clear that the arteries contain not only a pneuma, but also blood: "As for Erasistratus' views on arteries, views which contradict obviousness and challenge it, since I have spoken against them not once, not twice, but many times, I thought it needless to return to them" [21, p. 249]. The heart, which pumps blood not only into the lungs (as Erasistratus understood) but also into the arterial channel, causes pulsation of the arteries and respiration: "Therefore, it is possible that with respect to the heart, the vessel which contains blood retains the natural heat of the left cavity, heat which, as we have demonstrated, causes breathing and pulse in living beings. All this clearly proves that nature has built everything very thoughtfully, that the truth always agrees with itself and that Erasistratus' claims of the complete absence of mixing of matter agree with neither facts nor with themselves" [21, p. 255].

Within the teleological model of the human body, the question of which organ veins and arteries originate in and which direction the final topography of the vascular bed develops is of great importance. According to Galen, the root of the venous system is the liver, but according to Erasistratus, arteries grow from the heart: "6.6.23. Could he say that the veins have the heart as their source because at their first formation their origin is from the heart? But the inquiry, as initially defined at the beginning of the first book, was not concerned with this kind of source, Erasistratus did not even undertake to give a proof that nature, in forming the fetus, caused veins to grow from the heart" [15, p. 199].

In the same context, Erasistratus' rather vague notions of the role of the heart in breathing should be considered. The character of his views we can judge by the following passage from Galen's treatise "The Function of the Parts of the Body": "In fact, if these arteries are completely devoid of blood, like the trachea – as Erasistratus suggests – why does the trachea not end directly at the heart? Why do small radicles also penetrate into the trachea but not into smooth arteries? Nature, which does nothing without purpose as Erasistratus admits, therefore created not only smooth pulmonary arteries, but veins as well for no purpose at all: the former (arteries) because the heart, which is able to directly link to the trachea, would not have needed smooth arteries; the latter (veins), because, as he claims, the membrane of the trachea and generally arteries of all parts of the body, being tissue consisting of veins, arteries and nerves, each as such is fed by the vein contained therein – the vein which is simple and imaginary – and does not need connection of the large and complex veins. <...> After all, not to mention other arguments, those who would have wished to defend Erasistratus would have demonstrated their groundlessness by claiming that the trachea, which is made of cartilage, cannot connect to the heart. In fact, tracheal rings could have been joined to the heart in the same way as they are joined to each other by membranous bodies. Why then are arteries in the lung not homogeneous? Furthermore, why does the lung need veins? Erasistratus would not be able to answer these questions"[21, pp. 264–265].

Erasistratus denies the value of internal heat – one of the important components of the teachings of the followers of Hippocrates. Accordingly, the semantic structure disintegrated, within the framework of which the harmonious interrelation between the functions of respiration and blood circulation was clear. According to Erasistratus, the intrapulmonary vascular bed and the tracheobronchial tree exist outside the functional community – they are just inside the lung tissue. Therefore, Galen suggests that the trachea and bronchi are connected directly to the heart – apart from their function, they are just hollow tubes. Why in this case could one not imagine that the lungs are connected to the heart, not through veins and "venous-like arteries", but with the help of hollow tubes continuing from the trachea?

Part of this general misconception of Erasistratus' is the judgment that there is no blood in the left ventricle of the heart:

"1.6.1. For the statement of Erasistratus and his school, that before being laid bare it contained only pneuma, and that blood slips in after it has been laid bare, is nothing but the talk of men who are shameless in the face of refutation" [14, p. 179]. This statement is connected with

the judgment about the absence of blood in the arteries.

Galen greatly appreciates Erasistratus' description of the opening of the heart valves – he calls them "films" or "membranes":

"6.6.4. The observation has been recorded by Erasistratus in his treatise On Fevers, that there are membranes attached to the mouth of the vessels used by the heart for bringing matter in and sending it out again.

6.6.5. Some dared to say that these membranes do not exist, and that the account was interpolated by a follower of Erasistratus in order to support a view; yet they have come to be so well known to all physicians that anyone who does not rcognize them would appear to be really ancient.

6.6.6. At the mouth of the vena cava there are three (membranes), very similar in arrangement to the barbs of arrows; and for that reason, I believe, some of the Erasistrateans called them three-barbed (tricuspid). <...>

6.6.8. According to Erasistratus' explanation of this observation, each of these others is an exit, one of them carrying blood to the lungs, the other, pneuma to the whole body. The use of the membranes, as he thinks, is to provide to the heart opposite services, which alternate at suitable intervals of time. The membranes attached to the vessels that bring matter into the heart move from the outside in and are overcome by the influx of matter; and as they fall back they open the entrances to the cavities of the heart and allow unobstructed movement to the matter that is being drawn to the heart" [15, p. 197].

Thus, with Galen's description and positive assessments of the works of Erasistratus, everything becomes clear: in this respect the works of the great Roman physician can be considered a reliable source. However, Galen mostly criticizes Erasistratus, and one should carefully consider what is a statement of Erasistratus' mistakes, and what is merely a consequence of Galen's excessive emotionality. In my opinion, one should compare Galen's comments with the well-known data confirmed by other credible sources on the theory and practice of the school of methodologists, and also pay attention to the structure of the texts of Galen himself (in some cases he criticizes Erasistratus, but does not cite specific facts). Sometimes he retells the work of the famous Alexandrian in detail and even quotes him at length. Therefore the information reported by Galen is credible.[11]

[11] The continuation of this article will be published in one of the following issues of the *History of Medicine*. – *Editor's note.*

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