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Lewis, Orly; Gregorić, Pavel

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The Context of *De Spiritu*

Orly Lewis

Humboldt-Universität zu Berlin

orly.lewis@hu-berlin.de

Pavel Gregoric

University of Zagreb

pgregoric@hrstud.hr

Abstract

This paper underlines the importance of the Pseudo-Aristotelian treatise *De spiritu* for our knowledge of early Hellenistic anatomical and physiological theories. We claim that the treatise verifies reports on certain 4th- and 3rd-century conceptions and debates otherwise attested only in later sources, and offers invaluable information on otherwise unknown ideas and discussions. Our claim is based on ten case-studies in which we explore the relation between the views found in *De spiritu* and known to us from other ancient sources, regarding ten specific topics. Following the results of our case-studies, we argue that *De spiritu* should be dated to the early decades of the 3rd century BC, after the circulation of the doctrines of Praxagoras of Cos, but before the discovery of the central nervous system by Herophilus and Erasistratus.

* Orly Lewis: Institut für Klassische Philologie, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany; Pavel Gregoric: Department of Philosophy, Centre for Croatian Studies, University of Zagreb, Borongajska 83d, HR-10000 Zagreb, Croatia. The authors would like to thank the Centre for Croatian Studies of the University of Zagreb, the Alexander von Humboldt Foundation and Philip van der Eijk for making research for this paper possible over an extended period of time. The authors are especially grateful to Martin Kuhar, David Leith, Hynek Bartos and Luciana Repici for their useful written comments on earlier versions of this paper.

Keywords

pneuma – connate *pneuma* – *neura* – vascular system – blood – pulse – respiration – anatomy – physiology – early Hellenistic medicine – Aristotle – Praxagoras – Herophilus – Erasistratus – Galen

1 Introduction

The early Hellenistic period (the last decades of the 4th and the 3rd centuries BC) was marked by intense discussions on the subjects of anatomy and physiology. The concepts of *pneuma*, *artēria*, *phleps* and *neuron* were central to these discussions, and they were revised in light of new theoretical and empirical findings. For instance, the concept of *pneuma* as a key physiological agent in the body began to emerge in that period, *artēriai* were identified as a system of vessels distinct from *phlebes*, and the term *neuron* began to be restricted to structures regarded as conduits of sensory information and motor impulses. These conceptual changes gave rise to debates such as those concerning the location and mechanism of pulsation, the precise content of *artēriai* as opposed to *phlebes*, the role and identification of *neura* and the functional differentiation of *pneuma* in different bodily structures.

Unfortunately, the works of the main protagonists of these debates in the early Hellenistic period – Praxagoras of Cos, Herophilus of Chalcedon, Erasistratus of Ceos – are now lost.¹ Apart from the later second-hand testimonies of these debates, mostly in Galen, we find evidence of these debates in the treatise *De spiritu* attributed to Aristotle. In fact, *De spiritu* appears to be our sole surviving first-hand evidence of these debates, and as such it is an important source of our knowledge of early Hellenistic medicine which merits close attention.² In the article “The Substance of *De spiritu*,” we have reconstructed the doctrines and arguments of *De spiritu* from the text, which is encumbered by the author’s loose and at places aporetic style, but also by lacunas and other

1 These three physicians are roughly dated to the last decades of the 4th century BC and the beginning or first half of the 3rd century BC. We know that Herophilus was a student of Praxagoras and a younger contemporary of Erasistratus (Heinrich von Staden, *Herophilus. The Art of Medicine in Early Alexandria* [Cambridge, 1989], 43–50, and Orly Lewis, *Praxagoras of Cos on Pulse, Pneuma and Arteries and his Role in the Development of Ancient Medicine*, D.Phil. thesis, Humboldt-Universität zu Berlin [Berlin, 2014], 2). On Praxagoras’ and Erasistratus’ particular dating, see nn. 70 and 75, below.

2 The treatise *On the Heart*, transmitted under the name of Hippocrates and probably written in the 3rd century BC, might be an exception, as it may reflect debates concerning vascular anatomy and the passage of various substances through the body.

problems in textual transmission.³ We have argued that the author's anatomical and physiological theory is built around the idea of three main systems in the human body. First, there is the system of *artēriai*, by means of which air is drawn into the body, changed into *pneuma* and distributed to different parts of the body, where it achieves different effects: cooling in the lungs, assisting digestion in the stomach, and replenishment of the connate *pneuma* throughout the body. Second, there is the digestive system, by means of which nourishment is taken, processed and concocted into blood, and through which residues are discharged. The central part of the digestive system is the system of *phlebes*, through which blood is distributed around the body, thus providing nourishment and growth. Third, there is the system of bones and *neura* which provides support for the body, encloses and protects vital organs, and makes movements of the limbs possible. We have argued, moreover, that the author holds the connate *pneuma* to be the airy component of bodily structures, which mixes with other "simple bodies" in various ratios, thus explaining differences in qualities and dimensions of different bodily structures. It is this connate *pneuma* in *artēriai* that accounts for sensation, we have proposed, and in *neura* that accounts for movements of the limbs.

Relying on our reconstruction of the theory of *De spiritu*, in this paper we turn to its historical context. We propose to explore the context of *De spiritu* through ten case-studies, by examining how the author's views on ten well-defined issues compare to the views reported in other sources. The case-studies in Section 2 will demonstrate that the treatise constitutes our earliest first-hand evidence for certain ideas and doctrines known to us only through later reports, and also our only evidence for certain ideas that are otherwise unattested. Moreover, the case-studies will enable us to say something about the dating and authorship of the treatise in Section 3.

2 The Case-Studies

2.1 Artēriai

The author of *De spiritu* clearly conceives of *artēriai* as a distinct system of vessels, which he distinguishes both anatomically and physiologically from the vessels he calls *phlebes*. This was no obvious idea at the time. The term ἀρτηρία was generally used in the 5th and 4th centuries BC to refer either to the wind-pipe and, more rarely, to particular singular vessels connected to the kidneys or

3 See Pavel Gregoric, Orly Lewis and Martin Kuhar, "The Substance of *De spiritu*," which is contained in this same fascicle, *Early Science and Medicine* 20.2 (2015).

testicles.⁴ The plural ἀρτηρίαί only rarely refers to vessels that we know as veins and arteries and was restricted for the most part to the bronchi.⁵ Even Aristotle, who distinguished the vessels extending from the left side of the heart (i.e., the arteries) from those extending from the right side of the heart (i.e., the veins) according to their appearance, awards them all the same function – transmission of blood – and refers to them indiscriminately as φλέβες.⁶

The identification of *artēriai* as a distinct system of vessels, and the physiological and terminological distinction between arteries and veins, is first attested for Praxagoras of Cos. Praxagoras referred to the aorta as the “thick (παχεῖα) *artēria*,” and to all of its branches as *artēriai*. He distinguished them from *phlebes* by their constant pulsating motion and their role as transmitters of *pneuma* rather than of blood and humours.⁷ The author of *De spiritu* also attributes these very same distinctive properties to *artēriai*. Whereas the basic conception of *artēriai* as a distinct pulsating system of vessels soon became an underlying concept of later medical thought, Praxagoras’ doctrine of the bloodless content of *artēriai* was not widely accepted. In fact, besides *De spiri-*

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- 4 For the windpipe, see, e.g.: “Hippocrates,” *Anat.* 1 (Duminil 208,1 = L. 8.538.1) (writings attributed to Hippocrates are cited by reference to the volume and page numbers in the Littré [L.] edition and, when available, also to the more recent edition, all listed, together with title abbreviations, in http://cmg.bbaw.de/online-publications/Hippokrates-Biblio_graphie_2015_02_19.pdf); Aristotle, *On the Soul* II.8, 420b29; for other vessels: *Carn.* 5 (July 191,20 = L. 8.590.11); cf. Aristotle, *History of Animals* III.1, 510a29–35 (following Balme’s reading of 510a31 – D.M. Balme. *Historia Animalium: Vol. 1* [Cambridge, 2000]).
- 5 Cf. Galen, *PHP* VI.8.49 (De Lacy 418,3–6 = K. 5.575.13–16) on this point (Galenic writings are cited by reference to the volume and page numbers in the Kühn [K.] edition and, when available, also to the page number in the more recent edition, all listed, together with title abbreviations, in http://cmg.bbaw.de/online-publications/Galen-Bibliographie_2015_02_20.pdf). In fact, in the treatises attributed to Hippocrates, it occurs only eleven times in the plural: for bronchi, e.g.: *Int.* 38 (L. 7.260.16–17); *Loc. hom.* 14.2 (July 54,15 = L. 6.304.1); for vessels: *Alim.* 31 (July 144,15 = L. 9.110.1).
- 6 Although Aristotle refers to the aorta as ἀορτή, this is for him the proper name of a particular φλέψ (e.g., *History of Animals* III.5, 515 a29–32; *Generation of Animals* II.4, 738a10–11). For the morphological distinction according to Aristotle, see *History of Animals* III.3, 513b7–11; III.5, 515a29–32.
- 7 Galen, *De dign. puls.* IV.2, IV.3 (K. 8.941–942, 950 = frs. 84, 9 in Fritz Steckerl, *The Fragments of Praxagoras of Cos and his School* [Leiden, 1958], hereafter: Steckerl); *De diff. puls.* IV.2 (K. 8.702.14–18 = fr. 28(a) Steckerl). Praxagoras distinguished them also by their sinewy (νευρώδης) appearance and extremities (Galen, *PHP* I.6.17–18 [De Lacy 80–82 = K. 5.188–189 = fr. 11 Steckerl]), much like Aristotle (*History of Animals* III.5, 515a29–32). For Praxagoras’ conception of *artēriai*, see Lewis, *Praxagoras*, 261–299.

tu, it is attested only for Erasistratus and his followers.⁸ Nevertheless, even those who rejected Praxagoras' theory that arteries contain only *pneuma* (e.g., Athenaeus of Attaleia, Archigenes of Apamea and Galen) still conceived of the arteries as the "*pneumatic*" vessels that contain only a small quantity of fine blood, and of the veins as the "*haematic*" vessels that contain a large quantity of coarse blood.⁹ Consequently, scholars consider Praxagoras and his conception of arteries as a milestone in the history of ideas concerning the vascular system.¹⁰

Given that the views of Praxagoras and Erasistratus have reached us only through later reports and citations, *De spiritu* constitutes the only first-hand testimony of the idea that *artēriai* contain only *pneuma* and no blood. Moreover, it is the earliest extant source for the conception of a dual vascular system distinguished anatomically, physiologically and terminologically. The author of *De spiritu* uses the word *artēria* to refer to any part of the system of air-ducts running from the mouth to the lungs, and from there all over the body. This system includes, in modern terms, the windpipe, the bronchi, some of the pulmonary vessels and some parts of the vascular system.¹¹ Thus, the author's use of the word *artēria* encompasses parts that belong to what we regard today as two sharply distinct systems (i.e., the respiratory and the vascular systems). This has led scholars to claim that there was an "ambiguity" and "confusion of the senses assigned to ἀρτηρία" on the author's part.¹² Similarly, it has been claimed that the author uses the term to refer to both the so-called "rough" *artēriai* (i.e., the windpipe and bronchi), in accordance with the old anatomi-

8 E.g., Galen, *De usu part.* VII.8 (Helmreich 1.390, 13–20 = K. 3.537, 4–11 = fr. 103 in Ivan Garofalo, *Erasistrati Fragmenta* [Pisa, 1988], hereafter: Garofalo).

9 See, e.g., C.R.S. Harris, *The Heart, and the Vascular System in Ancient Greek Medicine – from Alcmaeon to Galen* (Oxford, 1973), 333–334 and Owsei Temkin, "On Galen's Pneumatology," in idem, *The Double Face of Janus and Other Essays in the History of Medicine* (Baltimore, 1977; reprint of *Gesnerus*, 8 [1951], 180–189), 154–161, for Galen's theory; and Max Wellmann, *Die pneumatische Schule bis auf Archigenes* (Berlin, 1895), 139–140, for Athenaeus and Archigenes.

10 Praxagoras has been used by modern scholars as a reference point for dating different anonymous treatises according to their vascular terminology, e.g., Harris, *The Heart*, 53, 72 and Marie-Paule Duminil, *Le sang, les vaisseaux, le coeur dans la Collection Hippocratique* (Paris, 1983), 105–110; cf. Jacqueline Jouanna, *Hippocrate* (Paris, 1992), 437; Iain M. Lonie, *The Hippocratic Treatises "On Generation," "On the Nature of the Child," "Diseases IV"* (Berlin, 1981), 88.

11 See Gregoric, Lewis and Kuhar, "The Substance," Section 2.1.

12 Walter S. Hett, *Aristotle: On the Soul, Parva Naturalia, On Breath*, 2nd rev. ed. (London–Cambridge, MA., 1957), 484–485; J.F. Dobson, *De Spiritu* (Oxford, 1914), iii.

cal tradition, and the so-called “smooth” *artēriai* (i.e., the arteries), “in accordance with the new anatomy.”¹³

The author’s concept of *artēria*, however, is confused or ambiguous only in retrospect, if we import later conceptions into *De spiritu*. As noted above, the term *artēria* was commonly used to refer to the windpipe and (in the plural) to the bronchi as early as the 5th century BC (see above, n. 4), and the pulmonary *artēriai* connecting the heart to the lungs would have afforded a connection between the windpipe-cum-bronchi and the *artēriai* extending from the heart.¹⁴ Indeed, some of the terms that Rufus of Ephesus lists for the bronchi are included also on his list of terms used for the arteries (e.g., σήραγγες and ἀορταί).¹⁵ The connection between the *artēriai* and *pneuma*, found already in early medical sources as well as in the traditional use of the term for the main air-duct of the body (the windpipe), would have further encouraged the author to connect the “respiratory” *artēriai* to the “vascular” ones, or at any rate would not have encouraged him to think of them as separate.¹⁶

More importantly, it is not at all clear that this concept of the windpipe, bronchi and vessels as a continuous system had disappeared by the 3rd century BC. On the contrary, the windpipe, bronchi and pulmonary vessels were still generically called *artēriai* and distinguished by some writers by adding qualifying adjectives, τραχεῖαι (rough) and λεῖαι (smooth). Even Galen, in the 2nd century AD, speaks of all *artēriai* (the windpipe, bronchi and all vessels connected to the left side of the heart) as a continuous part of the respiratory system.¹⁷

In view of the terminology, then, and the early stages of the development of the concept of *artēriai* as a distinct system of vessels extending from the heart, the author’s picture of the connection between this system and the respiratory passages would not have been out of place in the late 4th and the 3rd centuries BC. It can be suggested that the author’s ideas and use of the term *artēria* reflect a transitional stage in which the vascular system was conceived as consisting of two types of vessels, but was not yet clearly distinguished from the respiratory passages that connect the lungs with the mouth and nose.

13 Amneris Roselli, [*Aristotele*]: *De spiritu* (Pisa, 1992), 10.

14 Regardless of whether this referred to the pulmonary veins or pulmonary arteries.

15 Rufus of Ephesus, *On the Names of the Parts of the Human Body* 160 and 208, pp. 155 and 163 Daremberg/Ruelle (references to Rufus of Ephesus and Ps.-Rufus are to: C. Daremberg & C.E. Ruelle, eds., *Oeuvres de Rufus d’Ephèse* [Paris, 1879]).

16 For the connection between vessels called *artēriai* and the airy content in the treatises attributed to Hippocrates, see Duminil, *Le sang*, 50–61.

17 E.g., Galen, *De anat. admin.* VII.1 (K. 2.589–590).

2.2 Neura

The author's conception of *neura* is rather unique. It shares some features with the Hippocratic-Aristotelian conception, and others with the conception of the Alexandrian physicians. The author restricts the term *neuron* to the solid, hard and elastic structures connected to the bones, which we would identify as ligaments and tendons. This is in line with Aristotle and the medical sources from the 5th and the 4th centuries. Moreover, like Aristotle and the early physicians, our author seems to picture *neura* as cords that mechanically move the bones.¹⁸ On the other hand, the author of *De spiritu* claims that movements of the limbs are produced by motor *pneuma* which is primarily found in *neuron* (ἐν ᾧ <scil. τῷ νεύρω> πρῶτῳ τὸ πνεῦμα τὸ κινητικόν, 485a7). The idea that *neura* contain *pneuma* is not found in any of the so-called Hippocratic treatises, in Aristotle or in Praxagoras, but it is well attested for later authors, such as Herophilus, Erasistratus and Galen. These authors identify *neura* with the structures we recognize as the nerves and picture them as conduits that communicate sensory information and motor impulses between the central organ and the periphery by means of *pneuma* flowing inside them.¹⁹ However, our author's conception of *pneuma* in *neura* appears to be quite different.

It is explicitly stated in *De spiritu* that "only *artēria* can receive *pneuma*, whereas *neuron* cannot" (483b12–13), and again that *artēria* is the only type of structure receptive of *pneuma* (483b18–19). This creates a glaring contradiction with the author's claim that *neura* are that "in which motor *pneuma* is found primarily" (485a7). To resolve this problem, we have argued in the preceding paper that the author takes *artēria* to be the only type of structure through which *pneuma* flows, whereas "motor *pneuma*" in *neura* is the connate *pneuma*, that is, the airy component of *neura* mixed with fire and other simple bodies in a particular ratio.²⁰ In short, we have argued that the author takes *neura* to contain *pneuma* at the level of composition, not as a conduit through which *pneuma* flows. If we are right about this, it is clear that the author's conception of the *pneuma* in *neura* is profoundly different from the Erasistratean idea of *neura* as conduits through which *pneuma* flows, accepted also by Galen and possibly by Herophilus, too.²¹

18 For Aristotle's picture of the system of bones and *neura* and how they produce movements of the limbs, see Pavel Gregoric and Martin Kuhar, "Aristotle's Physiology of Animal Motion: On *Neura* and Muscles," *Apeiron*, 47.1 (2014), 94–115.

19 Friedrich Solmsen, "Greek Philosophy and the Discovery of the Nerves," *Museum Helveticum*, 18 (1961), 184–197; von Staden, *Herophilus*, 159–160, 250–259.

20 See Gregoric, Lewis and Kuhar, "The Substance," Section 4.

21 Galen believed that the *psychic pneuma* flows inside the optic nerves and the nerves branching from the spinal cord at their initial parts closest to the spinal cord. He was less

Solmsen seems to suggest that the use of the term “motor *pneuma*” (τὸ κινητικὸν πνεῦμα, 485a7) is evidence of the author’s adoption of the conception of the Alexandrian physicians, or at any rate of his familiarity with it.²² We would bid caution here. There are reports that Herophilus and Erasistratus distinguished between two kinds of *neura*, sensory (αἰσθητικά) and motor or voluntary (προαιρετικά or κινητικά), but there is no evidence whatsoever that they made a further distinction between sensory (αἰσθητικόν) and motor (κινητικόν) *pneuma*. If the author of *De spiritu* came up with the term “motor *pneuma*” based on Herophilus’ and Erasistratus’ reference to “motor *neura*,” it would be very strange indeed that in *De spiritu* we do not find a single other trace of their doctrine of the nervous system. It is more likely, therefore, that the author chose to call the *pneuma* in *neura* “motor” (κινητικόν) because he subscribed to the general idea, found in Aristotle and some early medical sources, that *pneuma* is involved in motion, as are *neura*.

Moreover, while Herophilus and Erasistratus assigned both motion and sensation to *neura*, the author of *De spiritu* assigns no role in sensation to *neura*, explicitly asserting that *artēria* is the only type of structure that is sensitive (ἡ ἀρτηρία μόνον αἰσθάνεται, 483a24). The rest of the passage is very unclear, largely due to textual difficulties. It is hard to say whether the author thinks that it is *pneuma* passing through the *artēriai*, or *pneuma* at the level of composition, that makes them sensitive.²³ Either way, the author of *De spiritu* is again in line with the earlier sources, such as the “Hippocratic” *On the Sacred Disease* and *On Breaths*, Aristotle, Diocles and Praxagoras, who ascribe a role in perception to the vessels or to the substances they carry – blood or *pneuma* – and not to *neura*.²⁴ At the same time, however, the author of *De spiritu* diverges from the

certain, however, that it flowed also through the narrower nerves, in which he observed no perforation (Galen, *PHP* VII.4.1–25 [De Lacy 448–452 = K. 5.611–617]). In Herophilus the picture is less clear – see von Staden, *Herophilus*, 250–259 and Solmsen, “Discovery,” 185–188 and more generally in 184–197). For Erasistratus see Galen, *De fac. nat.* II.6 (Helmreich 171,17–19 = K. 2.97.3–5 = fr. 147 Garofalo), Solmsen, “Discovery,” 188–190) and Mario Vegetti, “L’épistémologie d’Érasistrate et la technologie hellénistique,” in Philip van der Eijk, H.F.J Horstmannshoff and P.H. Schrijvers, eds., *Ancient Medicine in its Socio-Cultural Context*, vol. 2 (Amsterdam–Atlanta, 1995), 463.

22 Solmsen, “Discovery,” 183, 186, 188); cf. von Staden, *Herophilus*, 253. The term τὸ κινητικὸν πνεῦμα is not found even in Galen or Rufus.

23 In Gregoric, Lewis and Kuhar, “The Substance,” Section 4, we suggest, with due caution, that the author inclines to the latter view.

24 For Aristotle, see discussion and references in Pavel Gregoric, *Aristotle on the Common Sense* (Oxford, 2007), 44–45. For the so-called Hippocratic corpus, see for instance: *Morb. sacr.* 4.2, 14.5 = 7, 17 Jones (Jouanna 12, 26–27 = L. 6.368, 388); *Flat.* 14 (Jouanna 123 = L. 6.112). For Diocles and Praxagoras, see Anonymous of Paris, *On Acute and Chronic Diseases* 3, 20 (pp. 18, 120 ed. Ivan Garofalo, *Anonymi medici de morbis acutis et chroniis* [Leiden,

earlier sources in that he deprives the vessels (i.e., the *phlebes* and *artēriai*) of one of their main roles in the earlier medical tradition, namely that of transmitting motor impulses.

Nevertheless, the way in which the *neura* perform their action, according to our author, is neither “Hippocratic,” nor Aristotelian, nor Alexandrian. In the so-called Hippocratic sources *pneuma* and *neura* are never discussed in relation to one another. In Aristotle the connate *pneuma* in the heart is said to expand and contract in reaction to perceptual alterations, thereby pushing and pulling the tiny *neura* in the heart. This initial mechanical impulse generated in the heart is then somehow augmented on its way to the periphery, where it effects pulling and relaxing of *neura* which are attached to the bones.²⁵ Our author, by contrast, thinks that the connate *pneuma* is inside *neura*, apparently operating in some way at the level of composition. Consequently, our author’s view is not Alexandrian either, because Herophilus and Erasistratus thought that *neura* were hollow structures through which *pneuma* flows, carrying motor impulses from the brain.

Whatever the exact relation between “motor *pneuma*” and *neura* might be, what we find in *De spiritu* is a unique view of the way *pneuma* and *neura* interact. It is possible that the author developed his view in response to the problems in Aristotle’s explanation of the connate *pneuma*’s interaction with *neura*, or in response to the early physicians’ silence on the relation between *pneuma* and *neura*.²⁶ In either case, his response rests on an idea that is absent from all the other sources.

1997]). See also Philip J. van der Eijk, “The Heart, the Brain, the Blood and the *Pneuma*: Hippocrates, Diocles and Aristotle on the Location of Cognitive Processes,” in Philip J. van der Eijk, ed., *Medicine and Philosophy in Classical Antiquity* (Cambridge, 2005), 119–135, who discusses both Aristotle and the so-called Hippocratic corpus.

25 More on the role of the connate *pneuma* in Aristotle’s account of locomotion, see: Sylvia Berryman, “Aristotle on *Pneuma* and Animal Self-Motion,” *Oxford Studies in Ancient Philosophy*, 23 (2002), 85–97; Klaus Corcilus and Pavel Gregoric, “Aristotle’s Model of Animal Motion,” *Phronesis*, 58.1 (2013), 52–97; Gregoric and Kuhar, “Aristotle’s Physiology.”

26 The most acute problem in Aristotle’s theory (which was recognized already in antiquity) is that there is no continuity between the *neura* in the heart and the rest of the system of bones and *neura*, which seems to make the transmission of mechanical impulse from the heart to the periphery impossible, see, for example: Michael Frampton, “Aristotle’s Cardiocentric Model of Animal Locomotion,” *Journal of the History of Biology*, 24.2 (1991), 291–330; Gregoric and Kuhar, “Aristotle’s Physiology.” On the “gap” in the medical ideas between the vessels transmitting the *pneuma* carrying motor impulses and the *neura* acting upon these impulses, see Lewis, *Praxagoras*, 336–338).

2.3 *The Relation between Artēriai, Neura and Phlebes*

In *De spiritu* we find the claims that *artēria*, *phleps* and *neuron* are the three constituents of the skin (483b15–18), and that *artēria* and *phleps* are the two constituents of the flesh (484a33–34). The idea is that *phleps* makes a structure vascularized so that it contains blood (and hence bleeds when pricked), *artēria* makes it such that air can flow in and out of it, whereas *neuron* renders it elastic. These claims have been understood as reflecting the doctrine of *triplokia*, attested in our sources only for Erasistratus, and hence as strong evidence for dating the treatise to the period following the circulation of Erasistratus' doctrine.²⁷

In Erasistratus' doctrine, *neura*, *artēriai* and *phlebes* (jointly referred to as ἀγγεῖα) originate from the brain, left and right sides of the heart respectively, extend throughout the entire body and become so thin at their extremities so as to be invisible to the naked eye.²⁸ Thus, in the skin, in the flesh and in various organs we find these invisible *artēriai*, *phlebes* and *neura* "platted" or "woven" (πεπλέχθαι) together. Erasistratus believed that even the vessels themselves are made of all three constituents woven together, claiming that each macroscopic *artēria*, *phleps* and *neuron* is composed also of the other two counterparts, e.g., each visible *neuron* is made also of microscopic *phleps* and *artēria*, which provide it respectively with nourishment and *pneuma*.²⁹

Despite the *prima facie* similarity between the author's and Erasistratus' ideas, there are significant differences between them. First, our author seems to think that *neuron* is not found in the flesh (cf. 484a33–34), whereas Erasistratus takes *neuron* to be a part of the flesh as much as of any other tissue or organ. Second, in Erasistratus the *neura* in the so-called *triplokia* are the extremities of the nerves, i.e., cords extending from the brain and carrying *pneuma* with sensory information and motor impulses. Nothing in *De spiritu* suggests that *neura* have to be present in other tissues in order to communi-

27 Werner Jaeger, "Das *Pneuma* im Lykeion," *Hermes*, 48 (1913), 29–74, at 64; and Roselli, [*Aristotele*], 10, 102–103 n. ad 483b12 and b15). For the textual problems regarding the term *triplokia*, see Caroline Petit, *Galien. Le médecin. Introduction* (Paris, 2009), 130, n. 7.

28 Galen, *De usu part.* vii.8 (Helmreich 1.391 = K. 3.538); *De fac. nat.* ii.6 (Helmreich 171, 176 = K. 2.96, 2.103 = fr. 89 Garofalo); Ps.-Galen, *Int. s. med.* (Petit 20–21 = K. 14.697); Anonymous of London, XXI.23–28 (p. 46 Daniela Manetti, *Anonymus Londinensis: De Medicina* [Berlin–New York, 2011] = fr. 87 Garofalo); cf. Galen, *De resp. usu* 4.5 (Furley and Wilkie 158–160 = K. 4.716). For modern discussions of this doctrine, see Garofalo, *Erasistrati*, 32–35 and David Leith, "Erasistratus' *Triplokia* of Arteries, Veins and Nerves," *Apeiron* (forthcoming).

29 Anonymous of London, XXI.23–28 (p. 46 Manetti = fr. 87 Garofalo); Galen, *De fac. nat.* 2.6 (Helmreich 171 = K. 2.96 = fr. 89 Garofalo).

cate sensory information and motor impulses. The only reason stated in the *De spiritu* for the existence of *neuron* in the skin is its elasticity, presumably because *neuron* is the most appropriate type of structure to explain elasticity of a tissue. Third, Erasistratus' theory of *triplokia* was designed to explain how the arterial, venous and nervous systems interacted with each other.³⁰ There is no indication in *De spiritu* that the corresponding structures are thought to interact in any comparable way, or that this is a theory designed to account for some more complex physiological process.

In light of these differences, there seems to be no compelling reason for making the author's theory of the three constituents of the skin (and two constituents of the flesh) derivative from Erasistratus' theory of *triplokia*. Of course, we cannot entirely exclude the possibility that our author had been only superficially familiar with Erasistratus' version of the doctrine, or that he chose to adopt it only partially. However, given that Erasistratus' conception of *neura* as parts of the central nervous system is absent from *De spiritu*, it is much more likely that the opinion found in *De spiritu* was formed independently by our author, probably expanding on earlier ideas concerning the composition of tissues.³¹

2.4 *The Pulse*

The author considers the pulse, *σφυγμός*, a natural motion occurring primarily in the heart and derivatively in vessels of one type only, namely *arteriai*. This idea is not found in any of the treatises attributed to Hippocrates, in which the throbbing motion of the heart and vessels was generally considered pathological, occurring in illness or emotional extremes, nor in Aristotle. Moreover, in the handful of sources in which such motion is described as natural and constant, it is said to occur in *all* vessels, due to their connection with the heart.³² The earliest author, as far as our sources attest, who con-

30 See, in particular: Leith, "Erasistratus."

31 For example, the idea that flesh contains invisible *phlebes*, and therefore bleeds when pricked, is found in Aristotle (*Parts of Animals* III.5, 668a30–32).

32 For the pulse as an unnatural motion, see, e.g.: "Hippocrates," *Epid.*, II.5.16 (L. 5.130.18–19); *Morb.* I.20 (Wittern 52,14 = L. 6.176.13) and see Duminil, *Le sang*, 311–16 and Orly Lewis, "The Practical Application of Ancient 'Pulse-Lore' and its Influence on the Patient-Doctor Interaction," in Georgia Petridou and Chiara Thumiger, eds., *Approaches to the Patient in the Ancient World* (Leiden, forthcoming); as a natural motion: *Carn.* 6 (July 192,12–13 = L. 8.592.4); *Cord.* 1 (Duminil 190,4–5 = L. 9.80.4–5); Aristotle, *On Respiration* 20, 479b28–480a15. In "Hippocrates," *Loc. Hom.* 3 (July 41,2–4 = L. 6.280.14–16) pulsation is described as a constant motion, but only of the vessels in the temple, due to their irregular anatomy.

ceived of the pulse as a natural motion of the heart and arteries alone is Praxagoras.³³

Further aspects in the author's conception of the pulse point to the Hellenistic (and later) medical tradition, in particular as represented by the doctrines of Praxagoras and of his pupil Herophilus.³⁴ First, the author's use of the term σφυγμός for both the *natural* motion of the heart and vessels and their *irregular* motion in illness or strong emotional states was not an obvious one, particularly not in Aristotelian or Erasistratean contexts, with which the treatise is most commonly associated. Aristotle referred to the irregular motion of the heart during emotional states (e.g., fear) as πήδησις, explicitly distinguishing it and its cause from the natural motion of σφυγμός. Erasistratus, on the other hand, is said to have used the term σφυγμός only with reference to the pathological motion of the heart during fever.³⁵ Other terms for the natural motion were available as well, such as σφύξις (which was used by Aristotle and other peripatetic authors interchangeably with σφυγμός) and παλμός (which was used, for instance, by the 4th-century physician, Aegimius of Elis).³⁶

Second, the author is familiar with the technical terminology used by medical authors to describe variations in the pulse during illness, including terms absent from the "Hippocratic" sources: ἀνωμαλία, πυκνός, ὀμαλός, σφοδρός, ἀραιός³⁷ and ῥυθμός. These key terms in ancient pulse-lore³⁸ are all used by the author of *De spiritu* (483a1–6), although it is respiration, not the pulse, that the author describes as πυκνόν, ὀμαλόν, σφοδρόν and ἀραιόν. Nevertheless, as Roselli points out, only the words πυκνός and ἀραιός are commonly used for describing respiration in the earlier sources, whereas σφοδρός is used only once ("Hippocrates," *Int.* 3, 7.176.L.) and ὀμαλός never. The latter, however, is used with

33 For example: Galen, *De diff. puls.* IV.3 (K. 8.723 = fr. 27(a) Steckerl). The author of *De spiritu* differs from Praxagoras on the point of the relation between the cardiac and arterial pulsation (see below, nn. 41–42).

34 Jaeger, too, notes that in the case of the pulse, the author follows Praxagoras rather than Erasistratus, with whom, according to Jaeger, the author's doctrines are more often related (Jaeger, "Pneuma," 67).

35 For Aristotle, see for instance: *On Respiration* 20, 479b27, 480a14; *Generation of Animals* v.2, 781a25; For Erasistratus: Galen, *De diff. puls.* IV.17 (K. 8.761.3–5 = fr. 208 Garofalo).

36 For Aegimius: Ps.-Rufus of Ephesus, *Synopsis on the Pulse* (p. 219,2–6 Daremberg/Ruelle); Galen, *De diff. puls.* IV.11 (K. 8.751).

37 Following Jaeger's and Roselli's reading.

38 On these and other terms, see: Harris, *The Heart*, 244–51, 397–405; von Staden, *Herophilus*, 273–288.

reference to the pulse once in *De spiritu*, at 483a6, and often in later sources, along with σφοδρός.³⁹

Third, his discussion of the cause of the pulse and its relation to other physiological processes attests to ideas first ascribed to Praxagoras. The author of *De spiritu* distances himself from the Aristotelian position, which perceives the pulse as a mere byproduct of digestion, and argues instead that: “Pulsation looks like an *energeia*, and not like an entrapment of *pneuma* <i.e., not like the accidental result of the release of the *pneuma* trapped in the nutritive liquid>, unless perhaps the latter contributes to the *energeia*.”⁴⁰ So our author seems to think, against Aristotle, that the pulsating motion of *pneuma* has a definite function, although he is uncertain what it is. This idea, too, may be identified in the doctrines of Praxagoras and Herophilus, who regarded the pulsation as a δύναμις of *artēriai* and connected it with the process of supplying the body with *pneuma*.⁴¹

In addition, the discussion of the relation between the pulsation in the heart and that in *artēriai* (482b14–16, 30–34, 483a15–16) appears to reflect a debate among the medical authors of the time concerning the source of pulsation, for which Galen is our only source. The predominant view, still prevailing in Galen’s time, was that the pulse in *artēriai* was due to a *dunamis* in the structure of the vessel itself, whereas Erasistratus claimed that it was simply a result of the flow of *pneuma*, caused by the heart contracting and thus propelling *pneuma* through the system of *artēriai*. Moreover, among those who ascribed the motion of *artēriai* to some *dunamis* of the structure itself, rather than to the flow of *pneuma*, there was a controversy as to whether *artēriai* receive this *dunamis* from the heart through their walls, or whether they themselves hold an innate faculty to pulsate.⁴² The urgency of the author of *De spiritu* to prove the independence of pulsation from respiration (483a11–18) may be an attempt to argue against the theory that pulsation is simply the motion of *pneuma*

39 Roselli, [Aristotele], 95, n. ad 482b36. For the terminology in later authors, see the previous note.

40 483a17–18: καὶ <scil. ὁ σφυγμός> ἔοικεν ἐνεργείᾳ τινὶ καὶ οὐκ ἐναπολήψει πνεύματος, εἰ μὴ ἄρα τοῦτο πρὸς τὴν ἐνέργειαν. For the Aristotelian view according to which the release of the *pneuma* trapped in the nutritive liquid as the latter is heated causes the motion of the heart, which in turn moves the vessels, see Aristotle, *On Respiration* 20, 479b26–480a15.

41 Praxagoras and Herophilus considered pulsation to be a *dunamis* of the arteries, by means of which *pneuma* is drawn from the heart into these vessels, and hence further into the body (Galen, *De diff. puls.* IV.2 [K. 8.702–703 = fr. 28(a) Steckerl = fr. 155 von Staden, *Herophilus*]; *ibid.* IV.6 [K. 8.733 = fr. 144 von Staden]; *PHP* VI.7 [De Lacy 404–406 = K. 5.560–562 = fr. 28(b) Steckerl]).

42 Galen, *PHP* VI.7.1–9 (De Lacy 404–406 = K. 5.560–562); *De diff. puls.* IV.2 (K. 8.701–703).

through the *artēriai*. At the same time, the author's claim that the pulsation in other parts of the body is derived from the heart may reflect his siding with those who thought that *artēriai* received this *dunamis* from the heart, against those who thought that *artēriai* have an innate *dunamis* to pulsate.

2.5 *How Phlebes Deliver the Nutriment*

In 483b26–28 the author of *De spiritu* claims that the nutriment (i.e., blood) is delivered through *phlebes* to the flesh “not from their sides, but from their mouths, like pipes.”⁴³ Jaeger and Roselli claim that this is an argument directed against Erasistratus, since Galen offers a verbatim citation of Erasistratus claiming that vessels (the Erasistratean ἀγγεία) draw in nutriment “through their sides” (κατὰ τὰ πλάγια).⁴⁴ There are, however, reasons to resist the inference of Jaeger and Roselli.

First, Erasistratus was not the first to refer to the distribution of content through the sides of the vessels; this idea can be found already in Aristotle. According to Aristotle, “as the nutriment oozes through *phlebes* – i.e., through the pores in each of them, just like water in unbaked ceramic vessels – it becomes flesh.”⁴⁵ The comparison with water leaking from unbaked ceramic vessels implies that Aristotle is not thinking of nutriment flowing out through the mouths of the vessels, but through the pores in their walls.⁴⁶ A similar idea is ascribed to Praxagoras by the so-called Anonymous of Paris.⁴⁷

Second, in Galen's report, Erasistratus claims that it is only the microscopic vessels which draw their nourishment through their sides from the other microscopic vessels attached to them (i.e., a microscopic *artēria* from the nearby microscopic *phleps*). He refers explicitly to the “last, simple, fine and narrow” vessels (τοῖς δ' ἐσχάτοις τε καὶ ἀπλοῖς, λεπτοῖς τε καὶ στενοῖς οὖσιν), which are the microscopic *artēriai*, *phlebes* and *neura* that enter the composition of larger structures, including the macroscopic *artēriai*, *phlebes* and *neura*, as we have explained in Section 2.3 above. The fragment from Galen, tells us that this exchange of substances occurs through the sides, whereas their mouths are presumably preserved for the actual organ to which they extend.⁴⁸

Thus, while Erasistratus applies the idea of distribution of content through the sides of vessels to the microscopic level only, the author of *De spiritu* seems

43 ἐκ δὲ τῶν φλεβῶν εἰς τὰς σάρκας διαδίδοσθαι τὴν τροφήν, οὐ κατὰ τὰ πλάγια ἀλλὰ κατὰ τὸ στόμα, καθάπερ σωλήνας.

44 Jaeger, “*Pneuma*,” 66; Roselli, [*Aristotele*], 105 n. ad loc.

45 Aristotle, *Generation of Animals* II.6, 743a8–10: διὰ μὲν οὖν τῶν φλεβῶν καὶ τῶν ἐν ἐκάστοις πόρων διαπιδύουσα ἢ τροφή, καθάπερ ἐν τοῖς ὤμοις κεραμίοις τὸ ὕδωρ, γίνονται σάρκες.

46 Aristotle, *Parts of Animals* III.5, 668a27–b1; cf. *History of Animals* III.5, 515b1–3.

47 Anonymous of Paris, *On Acute and Chronic Diseases* 30 (Garofalo 164,2–5 = fr. 79 Steckerl).

48 See above, Section 2.3.

to be concerned with the traditional role of *phlebes* as conduits of nutriment to the flesh. Hence, it is not necessary to assume that the statement by the author of *De spiritu* was directed against Erasistratus. It seems, in fact, more likely to have been directed at the doctrine propounded by authors such as Aristotle and Praxagoras.

2.6 *Pneuma and Its Differentiation*

Our reconstruction of the theory of *De spiritu* includes an idea absent from the earlier sources, namely, the idea of differentiation of *pneuma*. According to our reconstruction, the author of *De spiritu* distinguishes between *pneuma* that percolates through the system of *artēriai* and *pneuma* that he calls “connate” (σύμφυτον) or “innate” (ἔμφυτον). The percolating *pneuma* comes from respiration, it is involved in digestion and provides nourishment to the connate *pneuma*. The connate *pneuma* exists before birth and serves as a component of the parts of the body. The author of *De spiritu*, we argue, further distinguishes between the connate *pneuma* mixed with other simple bodies in one particular ratio to compose *artēriai*, structures which have a certain set of qualities and which are sensitive, and in another ratio to compose *neura*, structures which have a different set of qualities and which are mobile. As we have seen, the latter is called at one place in *De spiritu* “motor *pneuma*” (485a7), with reference to its supposed function.

Authors of the 5th century and a large part of the 4th century BC do not seem troubled by the question of how one and the same substance can discharge different functions, whereas our author seems mindful of that question, much like the early Hellenistic philosophers and doctors. Galen distinguished between the “vital *pneuma*” (ζωτικὸν πνεῦμα) in the arteries and the “psychic *pneuma*” (ψυχικὸν πνεῦμα) in the *neura* (i.e., nerves). He considered the former to be a mixture of respired and transpired air with the air produced by the vaporization of blood, and the latter to be produced from the rarefaction and purification of the “vital *pneuma*” in the arteries leading to the brain, as well as from air inhaled through the nostrils directly to the brain, without being affected by the blood and other substances in the arteries.⁴⁹ Galen ascribes the term “psychic *pneuma*” to the Stoic philosopher Chrysippus of Soli, and both terms – “vital” and “psychic” *pneuma* – to Erasistratus. However, the context of these passages and Galen’s rhetoric in them suggest that these might be dubious attributions.⁵⁰

49 Galen, *PHP* VII.3.28 (De Lacy 444,33–446,1 = K. 5.608.5–7).

50 Galen, *In Hipp. Epid. VI comment.* VI.6.3 (Wenkebach 327,12–14 = K. 17B.320.4–6, comment on “Hippocrates,” *Epid.* VI.1 [Manetti/Roselli 122 = L. 5.322.9–10]); *PHP* I.6.3, II.8.38 (De Lacy 78,24–26, 164,13–16 = K. 5.185.5–7, 281.3–6).

De spiritu does not use either of these terms, and hence it is of no help in determining whether they were already in circulation in the early 3rd century BC. However, our treatise seems to reflect an early stage of the elaboration of the concept of *pneuma* with reference to its different kinds and to its different physical properties in different structures, in which it executes different functions. According to our reconstruction of the theory of *De spiritu*, the author holds, just like Galen, that the *pneuma* derived from respiration serves as “nourishment” for the *pneuma* involved in sensation and locomotion (the connate *pneuma*). Moreover, like the Alexandrian and later physicians, our author explains sensation and locomotion by the same kind of *pneuma* acting in different structures. As we have seen, our author assigns sensation and locomotion to the connate *pneuma* constitutive of *artēria* and *neuron* respectively. Similarly, Erasistratus and Galen assigned sensation and locomotion to the psychic *pneuma* in two different kinds of *neura*.

It seems, therefore, that *De spiritu* offers an early testimony to the idea of differentiation of *pneuma* – not only the differentiation between the respiratory and the connate *pneuma*, but also the differentiation of the connate *pneuma* into that which is involved in sensation and that which is involved in locomotion. Nevertheless, the way the connate *pneuma* is involved in these two functions, if our reconstruction of *De spiritu* is correct, is importantly different from the way Erasistratus and Galen envisaged *pneuma* to be involved in these two functions.

2.7 *The Concept of the Connate Pneuma*

De spiritu opens with the questions how the connate *pneuma* is maintained and how it grows. These questions merit attention, “for we can see that it grows and becomes stronger both with age and with the condition of the body.”⁵¹ Of course, we can “see” this only if we take it for granted that there is such a thing as the connate *pneuma*, and that it is the source of strength in animal bodies. Both of these ideas are found in Aristotle and probably originate with him.⁵² In fact, the term “connate *pneuma*” (σύμφυτον πνεῦμα) is first attested in the writings of Aristotle, in whose doctrines it plays a central role.⁵³ However, we do

51 481a2–3: ὁρώμεν γὰρ ὅτι πλέον καὶ ἰσχυρότερον γίνεται καὶ καθ’ ἡλικίας μεταβολὴν καὶ κατὰ διάθεσιν σώματος.

52 See Aristotle, *Movement of Animals* 10, 703a8–10; *On Sleep and Waking* 2, 456a15–17; *Generation of Animals* II.4, 737b32–738a1; V.7, 787b10–788a16.

53 In 481a1 the author of *De spiritu* refers to ἔμφυτον πνεῦμα, but there is no indication that he regards this as any different than the σύμφυτον πνεῦμα, which he uses more often (481b19, 482a8, 22, 33). Indeed, also in Aristotle and Galen these terms seem to be used interchangeably.

not find this term in our testimonies of the prominent physicians of the 4th and 3rd centuries BC such as Diocles of Carystus, Praxagoras, Herophilus and Erasistratus.

Aristotle's conception of the connate *pneuma* is still a matter of much debate.⁵⁴ Very briefly, it is a warm airy substance inside the animal body, present in an animal from its earliest embryonic stage. It is found in semen and it carries out the earliest phase of differentiation of parts in the embryo. Apart from its role in reproduction, it also plays a role in perception, as some passages that connect the peripheral senses with the system of blood-vessels are said to be filled with it. Presumably, in these passages the connate *pneuma* serves as a medium of sensible forms. And, as we have mentioned, the connate *pneuma* in the heart plays a crucial role in locomotion (see Section 2.ii above).

In our author's theory, as much as in Aristotle's, the connate *pneuma* plays a role in locomotion and perception, but the way he envisages it to discharge these roles is importantly different from what we find in Aristotle. According to the author of *De spiritu*, if we have reconstructed his theory correctly, the connate *pneuma* does its work in the *artēriai* and *neura* at the level of composition. Such an idea is found neither in Aristotle nor in any of the medical sources.⁵⁵

2.8 *A Debate on How the Connate Pneuma is Nourished*

De spiritu offers the sole testimony to a debate concerning the sources of nourishment for the connate *pneuma*. The treatise opens with the questions how the connate *pneuma* is nourished and how it grows. These questions seem to go back to a parenthetical remark in Aristotle's *Movement of Animals* 10: "How the connate *pneuma* is preserved is stated elsewhere" (703a10–11).⁵⁶ Clearly, the inquiry into the source of growth and nourishment of the connate *pneuma* is very important: if the connate *pneuma* is a warm airy substance with which

54 A.L. Peck, *Aristotle: Generation of Animal* (London–Cambridge, MA, 1942), 578–593; Friedrich Solmsen, "The Vital Heat, the Inborn *Pneuma* and the Aether," *Journal of Hellenic Studies*, 77.1 (1957), 119–123; Gad Freudenthal, *Aristotle's Theory of Material Substance: Heat and Pneuma, Form and Soul* (Oxford, 1995), 106–148; Abraham P. Bos, *The Soul and its Instrumental Body: A Reinterpretation of Aristotle's Philosophy of Living Nature* (Leiden, 2003).

55 The role of the connate *pneuma* in reproduction is curiously missing from *De spiritu*. The only hint at such a role is a disconnected remark at the beginning of Chapter 6, 484a14–15 (see Geric, Lewis and Kuhar, "The Substance," 123).

56 If this remark is a reference to *De spiritu*, it might be a later interpolation by an editor or scribe who knew of the existence of *De spiritu*. This, and a similar parenthetical promissory remark a few lines down, at 703a16–18, ostensibly spoil the train of Aristotle's thought.

one is born, it is likely that its bulk increases with the rest of the body. Moreover, as the body matures, its parts grow larger and require more strength to be moved; if the connate *pneuma* is the source of strength in the body, it too must grow in bulk, in order to provide more strength to the growing body. Finally, if the connate *pneuma* is a material substance like any other part of the body, it should be subject to change and waste, and hence in need of maintenance (cf. 481a9–10). Hence, it is pertinent to inquire about the source of growth and nourishment of the connate *pneuma*, and that is one of the tasks that the author of *De spiritu* sets for himself.

The author considers two possibilities as to the source of growth and nourishment of the connate *pneuma*: through digestion and through respiration. Both options are examined in Chapters 1 and 2, and they are both found to be problematic. The author is especially keen on refuting the theory that the inhaled air is turned into *pneuma* by undergoing concoction (πέψις) in the lungs, which is ascribed to Aristogenes.⁵⁷ The author launches a battery of arguments against Aristogenes' theory, which suggests quite strongly that there was a debate in the early Hellenistic period concerning the source of growth and nourishment of the connate *pneuma*, a debate to which *De spiritu* is our only witness.

Although the author's preferred view is not stated in Chapters 1–2, the implication of Chapters 3–5 seems to be that the connate *pneuma* is ultimately nourished by respiration, only without undergoing any sort of concoction in the lungs. In a nutshell, our interpretation of these difficult chapters is that a portion of the inhaled air arrives at the lungs where it performs cooling. And whereas one heated portion of air is exhaled, another is distributed around the body through the system of *artēriai*, most probably with the help of pulsation, for the purpose of nourishing the connate *pneuma* from which bodily parts are constituted.⁵⁸

This position is interesting because it shows that the author of *De spiritu* answers an open question in Aristotle's theory by drawing upon the idea that inhaled air spreads throughout the body – an idea common in early and late medical sources, but absent from Aristotle.⁵⁹

57 This is probably Aristogenes of Cnidus, the pupil of Chrysippus of Cnidus and the personal physician of Antigonos Gonatas, the ruler of Macedonia from 276 to 240 BC – see: Max Wellmann, "Aristogenes," *RE* II.1 (1895), 932–933; Jaeger, "Pneuma," 73–74; Roselli, [*Aristotele*], 76–79; cf. Abraham P. Bos and Rein Ferwerda, *Aristotle on the Life-Bearing Spirit (De Spiritu). A Discussion with Plato and his Predecessors on Pneuma as the Instrumental Body of the Soul* (Leiden, 2008), 9–11.

58 More on this in Gregoric, Lewis and Kuhar, "The Substance," Sections 3–4.

59 Aristotle believed that respired air cools the chest area and maintains the innate heat by

2.9 *How Pneuma Reaches the Stomach*

The Anonymous of London claims that a small amount of *pneuma* enters the stomach (κοιλία, XXIII.16, p. 50 Manetti). More specifically, he states that it enters the stomach through the esophagus (στόμαχος), in explicit contrast to Erasistratus' opinion: "Some [i.e., *pneuma*] seeps through to the stomach as well, according to us through the esophagus, unlike Erasistratus."⁶⁰ Unfortunately, the details of Erasistratus' opinion are not explicated. The formulation could imply either that Erasistratus did not think that any *pneuma* reached the stomach from respiration (cf. Manetti 2011: xv), or that he did not think that it reached the stomach through the esophagus, but through some other route.

De spiritu offers a clear testimony for a debate concerning the second question, arguing, in fact, against the very position supported by the Anonymous of London. According to *De spiritu*, *pneuma* from respiration is carried to the stomach "not through the esophagus – since this is impossible – but through a passage along the loin (πῶρος παρὰ τὴν ὀσφύν, 483a20–21)." We have argued that this passage was a theoretical entity postulated by the author of *De spiritu* in order to explain the presence of a sizeable quantity of *pneuma* in the stomach.⁶¹ While these lines cannot solve the riddle of Erasistratus' view, they attest to the existence of a debate concerning the entry route of *pneuma* to the stomach.⁶² *De spiritu* happens to be our only witness for the particular anatomical view that *pneuma* enters the stomach through a "passage along the loin."

2.10 *The Role of Respiration*

A debate concerning the role of respiration is well attested in our sources.⁶³ Chapters 2 and 3 of *De spiritu* constitute important evidence in the history of

reaching as far as the lungs and without entering the heart or the vessels. The only air in the heart, according to his theory, is generated inside it from the pneumatization of blood (*On Respiration* 20, 479b16–480a10).

60 Anonymous of London, XXIII.16–18 (p. 50 Manetti): διηθ[εῖται] [scil. πνεύμα] δὲ καὶ εἰς κοιλίαν ὀλίγον διὰ τοῦ [στομά]χου καθ' ἡμᾶς, οὐ μὴν δὲ κατὰ τὸν Ἐρ[α]σίστρατον.

61 "The Substance of *De spiritu*," Section 2.1.

62 An idea that we do find in our sources is that liquids reach the lung through the windpipe (Plato, *Timaeus* 70c); "Hippocrates," *Cord.* 2–3 [Duminil 190–191 = L. 9.80–82]), Erasistratus in Plutarch, *Table Talk* VII.1, 698a-b, ed. F. Fuhrmann, *Plutarque: Oeuvres morales*, vol. IX 1 (Paris, 1972) (= fr. 114 Garofalo). Aristotle refutes this idea (*Parts of Animals* III.3, 664b9–12) and notes that this is impossible also on account of anatomy, because there is no passage from the lung to the stomach. It was perhaps this statement of Aristotle that motivated the author of *De spiritu* to note that the passage distributing *pneuma* to the stomach splits off from the windpipe before the bronchi, that is, *before* the lung.

63 Aristotle's treatise *On Respiration* is dedicated to this question and discusses earlier opin-

this debate after Aristotle, for which our main source is Galen's treatise *On the Use of Respiration*. In this treatise Galen distinguishes between two main positions: the position that the role of respiration is to maintain the *pneuma* or the soul by contributing the substance which "nourishes" or "replenishes" it (Asclepiades of Bithynia, Praxagoras, Erasistratus), and the position that the role of respiration is to maintain the innate heat by cooling it (Philistion of Locri, Diocles of Carystus); "Hippocrates" is said to have taken both positions, and he is followed by Galen.⁶⁴ Galen's presentation, however, has a somewhat artificial quality to it, which has led scholars to question its reliability, especially in light of other Galenic and non-Galenic sources, and of Galen's tendency to present "staged debates," which did not necessarily take the clear course depicted by him.⁶⁵

Chapter 3 of *De spiritu*, however, corroborates Galen's distinction between these two main positions on the role of respiration. Having rejected in Chapter 1 the possibility that the connate *pneuma* is nourished by digestion, in Chapter 2 our author considers the possibility that it is nourished by respiration. The variant of this possibility that our author immediately introduces, and then attacks on many accounts, is Aristogenes' theory of concoction of inhaled air in the lungs.⁶⁶ In Chapter 3 the author turns to respiration as such, expressing his dissatisfaction with theories of Empedocles and Democritus who failed to state the function of respiration. Apparently, the author of *De spiritu* is dissatisfied also with Aristotle, who thought that the one and only function of respiration is cooling, whereas our author seems to think that a further function of respiration is to provide nourishment for the connate *pneuma* (482a31-b2). In Aristotle's entire corpus we do not find any indication of the idea that respiration nourishes the connate *pneuma*, or any other kind of *pneuma* for that mat-

ions on the topic (namely of Democritus, Anaxagoras, Diogenes, Plato and Empedocles). Galen's treatise *On the Use of Respiration* is similarly focused on this question and argues against the opinions of earlier physicians.

64 Galen, *De resp. usu* 1.2 (Furley and Wilkie 80 = K. 4.471).

65 On the problems in Galen's passage see: Armelle Debru, *Le Corps respirant: Le pensée physiologique chez Galen* (Chicago, IL, 1996), 147–176; Philip J. van der Eijk, "Some methodological issues in collecting the fragments of Diocles of Carystus," in Antonio Garzya and Jacques Jouanna, eds., *I Testi medici greci. Tradizione e ecdotica* (Naples, 1999), 147–148, and *Diocles of Carystus: A Collection of the Fragments with Translation and Commentary*, vol. 2: Commentary (Leiden, 2001), 63–66; Lewis, *Praxagoras*, 202–203; cf. Teun Tieleman, *Galen and Chrysippus on the Soul: Argument and Refutation in the De Placitis, Books 2–3* (Leiden, 1996), 70, 101–102, for Galen's method in presenting such debates.

66 On Aristogenes' opinion and the author's arguments against it, see Section 2.8, above.

ter.⁶⁷ However, this idea of respiration providing nourishment to *pneuma*, with the explicit talk of the τροφή of *pneuma*, is found in the “Hippocratic” treatise *De alimento* and it is ascribed by Galen to Praxagoras and Erasistratus.⁶⁸

Even if Aristogenes did not originally propose his particular doctrine in order to argue against the Aristotelian view on the role of respiration, our author does juxtapose the two basic ideas juxtaposed by Galen: respiration for the purpose of maintaining *pneuma* by nourishing and replenishing it, as opposed to respiration for the purpose of maintaining the innate heat by cooling it. This juxtaposition in Chapter 3 of *De spiritu* thus serves as independent evidence that such opinions did exist and were proposed also in the context of the debate on the role of respiration. It indicates, therefore, that Galen’s juxtaposition of these two opinions was not his own anachronistic rhetorical manipulation of the evidence. If our interpretation of the author’s opinion is correct, the author of *De spiritu* sides with the first group. Moreover, the fact that in Chapter 2 he wants to dissociate himself from another author from the same group, namely Aristogenes, constitutes further and independent evidence to the variety of opinions in the debate about the role of respiration.

3 Tentative Dating of *De spiritu*

We can be sure that the author of *De spiritu* is familiar with the works of Aristotle. The questions he raises, the terminology he uses, the concepts with which he operates, the methodology he follows, and some observations that he makes would be hard to imagine without first-hand knowledge of Aristotle’s treatises. Nevertheless, there are many examples of terminology, concepts and ideas that are alien to Aristotle, or even in flat contradiction with Aristotle’s attested views, e.g., the use of terms such as *artēria*, *phleps*, *sphugmos*, the function of the pulse, the role of respiration. Thus, while the author could not

67 The notion of respiration as *trophē* may be found in Chapter 6 of Aristotle’s *On Respiration*, but there it is the *trophē* of “the inner fire” (τοῦ ἐντὸς πυρός, 473a4), not of *pneuma*, and there is no indication whatsoever in this passage that this “inner fire” can be identified with *pneuma* or air; cf. Roselli, [*Aristotele*], 77–78, n. ad 481a29.

68 “Hippocrates,” *Alim.* 30 (July 144 = L. 9.108). According to Galen, Praxagoras believed that respiration provided nourishment to the “soul” or “psychic *pneuma*” (but Praxagoras himself had more likely referred simply to “*pneuma*,” see Lewis, *Praxagoras*, 351–352), and Erasistratus believed that the *pneuma* in the arteries is replenished by respired air (e.g., *De resp. usu* 1.2, 2.11 [Furley and Wilkie 80, 96 = K. 4.471, 483 = fr. 32 Steckerl = fr. 99 Garofalo]).

have been Aristotle himself, he must have post-dated him and was probably very closely associated with the Peripatetic school.⁶⁹

Moreover, in addition to a body of Aristotelian ideas, the author of *De spiritu* also seems to take for granted ideas first attributed to the physician Praxagoras of Cos, whose *floruit* is roughly dated to 300 BC; namely, the conception of *artēriai* as forming a distinct system of vessels that contains only *pneuma* and in which a natural but varying pulsating motion occurs.⁷⁰ The author of *De spiritu* is not concerned with providing a systematic account of this vascular system, but he does refer to those features or parts of the vascular system that are essential to his discussion of *pneuma*. Nevertheless, his use of the term *artēria* for the windpipe (see section 2.1 above), for example, or his claim that the pulsation in the *artēriai* derives from the heart's motion (482b33–34), suggests an author other than Praxagoras.⁷¹ There are also more general indications pointing to a philosophical rather than medical writer, e.g., the importance of the final cause, references to powers of the soul, acute interest in other animals and the absence of any reference to the pathological conditions related to *pneuma*.⁷²

If the Aristogenes mentioned in Chapter 2 is indeed the Cnidian doctor and the personal physician of Antigonus Gonatas, the Macedonian ruler between 276 to 240 BC, this sets a very broad *terminus post quem*. However, it is reasonable to assume that Aristogenes was appointed as Antigonus' physician only after he had made a name for himself, and hence after his doctrines were made

69 For arguments against its attribution to Aristotle, see Valentin Rose, *De Aristotelis Librorum–Ordine et Auctoritate* (Berlin, 1854), 167–171; Jaeger, “*Pneuma*,” 61–73, and Pavel Gregoric and Orly Lewis, “Pseudo-Aristotelian *De spiritu*: A New Case Against Authenticity,” *Classical Philology* 110 (2015), 159–167.

70 On the question of Praxagoras' dating, see Steckerl, *Praxagoras*, 1–4 and Lewis, *Praxagoras*, 2.

71 A verbatim fragment cites Praxagoras as using the term φάρυγξ for the windpipe (*Schol. ad Il.* XXII.325, vol. 2, p. 296 in Wilhelm Dindorf, *Scholía Graeca in Homeri Iliadem* [Leipzig, 1877] = fr. 10 Steckerl). For Praxagoras' claim that the beating of the *artēriai* is independent from the heart, see the references in n. 42 above.

72 The suggestion to identify the author as Strato of Lampsacus (c. 335–c. 268 BC) – first proposed by Franciscus Patricius in his *Discussiones peripateticae* (Basel, 1581; reprint: Köln–Weimar–Wien, 1999, 74) – has been rejected on the ground of doctrinal differences between Strato and our author (Georges Rodier, *La physique de Straton de Lampsaque* [Paris, 1890], 47–48; Fritz Wehrli, *Die Schule des Aristoteles. Heft V: Straton von Lampsakos* [Basel, 1974], 70). Our reconstruction of the theory of *De spiritu*, as far as we can tell, does not contain elements that obviously contradict the known doctrines of Strato, but we would hesitate nonetheless to defend the Stratonic authorship of *De spiritu*.

known. Thus, it is quite possible that another author could cite him already in the second decade of the 3rd century BC.

Jaeger pushes this *terminus post quem* into the second half of the 3rd century BC in light of his assumption that the author of *De spiritu* knew of Erasistratus' doctrines and reacted to them.⁷³ Roselli too, while refraining from any precise dating, notes that the treatise is a testimony to the debates "immediately following the anatomical discoveries of the Alexandrian."⁷⁴ We are reluctant to accept this dating and the proposed relation to Erasistratus because, as we have shown, the supposed evidence of *De spiritu*'s familiarity with Erasistratus' doctrines is rather tenuous. In particular, we have shown that neither the author's reference to the composition of skin and flesh, nor his talk of "motor *pneuma*" in *neura*, nor even the question whether *phlebes* deliver nutriment through the mouth or through their sides, can be taken as evidence of the author's familiarity with the doctrines of Erasistratus. It is more likely that *De spiritu* was written before Erasistratus made his doctrines public, or that the author developed his theories roughly at the same time as Erasistratus. If *De spiritu* were indeed written in the second half of the 3rd century, and with knowledge of Erasistratus' doctrines, it would be extremely difficult to explain why *De spiritu* makes no reference whatsoever to the doctrine of the nervous system, which had made Erasistratus famous. In light of our arguments, there appears to be no compelling reason to date the treatise in the mid-3rd century or later, and there are good reasons to date it to the early decades of the 3rd century, closer to Aristotle and Praxagoras.⁷⁵

4 Conclusion

We hope to have demonstrated the historical value of *De spiritu* as a source of our knowledge of physiological and anatomical theories in the early Hellenistic period. We have shown that it is our earliest evidence for a number of ideas that we find in later sources, mostly in Galen. As such, *De spiritu* allows us to verify the reports we find in our later sources. Also, we have shown that *De spiritu* is our sole evidence for a certain number of interesting ideas concerning human anatomy and physiology.

73 Jaeger, "*Pneuma*," 73; cf. *ibid.*, n. 1.

74 Roselli, [*Aristotele*], 12 (our translation from the Italian).

75 Jaeger, "*Pneuma*," 74; for a tentative dating of Erasistratus as a younger contemporary of Herophilus, see von Staden, *Herophilus*, 47–48; Max Wellmann, "Erasistratos 2," *RE* VI.1 (1907), 933.

We have argued that *De spiritu* constitutes our earliest first-hand testimony for: (i) a physiological and terminological distinction of two vascular systems; (ii) the idea that *artēriai* contain only *pneuma*; (iii) the conception of the pulse as a natural motion, pertaining to *artēriai*; (iv) the debates concerning the role of respiration after Aristotle and concerning the role and physiology of the pulse; (v) the rejection of the traditional view that vessels (*artēriai* and *phlebes*) convey motor impulses; (vi) the elaboration of the concept of *pneuma*, its differentiation and functional variegation.

In addition, *De spiritu* presents ideas and debates which are otherwise unattested in our sources: (i) the idea of composition of tissues, which only partially resembles Erasistratus' doctrine of *triplokia*; (ii) the incorporation of the Aristotelian concept of the connate *pneuma* into a general physiological theory, and its combination with the earlier medical view that air from respiration pervades the entire body; (iii) the idea that the connate *pneuma* is a component which mixes with other simple bodies in different ratios to produce different bodily structures, whereby it accounts for different properties and functions of these structures, most notably sensation in *artēriai*, and locomotion in *neura*; (iv) the existence of a debate concerning the source of nourishment of the connate *pneuma*; (v) the idea that there is a passage which extends from the windpipe and "along the loin" to the stomach, supplying the stomach with *pneuma* that derives from respiration.

It is clear that the author of *De spiritu* engaged with theories current at the time, and that he did so from a recognizably Aristotelian framework, drawing heavily on certain methodological assumptions, concepts, views and observations of Aristotle. Although the author is openly uncertain about many issues, he does not shun from criticizing others. His motivation seems to be to address a large open question in the Aristotelian theory (the source of nourishment of the connate *pneuma*), to probe possible answers suggested by others, and to put his own views on the table. These views were most probably intended to be seen as Peripatetic, presenting the Lyceum as a legitimate player in the field. Nevertheless, the author is an independent thinker ready to abandon or openly contradict views held by Aristotle, and to incorporate ideas propounded by the medical authors of the 5th, 4th and early 3rd centuries BC that were rejected or ignored by Aristotle himself, such as the dual vascular system or the diffusion of respired air throughout the body.

The style of *De spiritu* is at places aporetic and associative, with a tendency to pile up questions and ideas in a manner which often presupposes acquaintance with the current problems and theories, of which we have very fragmentary knowledge. Whether or not such style is due to early Peripatetic proclivity for dialectical discussion, *De spiritu* is a good example of the way in which

concepts and theories were forged. What we get in Galen, the *Placita* or the Anonymous of London are reports of these theories presented with the benefit of hindsight. And this is not always an unequivocal benefit, as such reports are prone, consciously or not, to distort the opinions of earlier authors by misunderstanding their terminology or by misrepresenting their concepts, taking them out of their original context or adapting them to the theories and concerns of later authors and compilers.

The scarcity and nature of our sources from the early Hellenistic period do not allow us to trace direct lines of influence between the author of *De spiritu* and thinkers who marked that period, notably Praxagoras, Herophilus and Erasistratus. Nevertheless, releasing this treatise from Erasistratus' shadow allows us to see it as a unique snapshot of the debates that had shaped anatomical and physiological theories in the period that preceded the empirical investigations which led Erasistratus and Herophilus to one of the most remarkable discoveries in antiquity, the discovery of the central nervous system.