BRILL

EARLY SCIENCE AND MEDICINE 20 (2015) 101-124

Early Science and Medicine
www.brill.com/esm

The Substance of *De Spiritu*

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Abstract

The aim of this paper is to depict the anatomical and physiological doctrines of the treatise entitled Περὶ πνεύματος, or *De spiritu*. By closely examining the contents of the treatise on its own accord, rather than through its Aristotelian or Hellenistic contexts, we attempt to overcome the aporetic and often disconnected style of the author, and to present a coherent picture of his doctrine of *pneuma*, its roles in the body, the anatomical structures in which it acts, and its relation to the soul. We argue that the author envisions three main systems in the body: *artēriai*, by which external air is taken in, turned into *pneuma* and distributed to different parts of the body; *phlebes*, by which

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 | DOI 10.1163/15733823-00202P01

blood is produced and distributed; bones and *neura*, which support the body and effect locomotion. *Pneuma* is shown to run through the system of *artēriai*, whereby it performs vital activities such as thermoregulation, digestion and pulsation. It is also engaged in activities such as perception and locomotion, in the form of the "connate *pneuma*," which, we propose, is a component of bodily parts. The author connects *pneuma* very closely with soul, and although he is familiar with Aristotle's doctrine of the soul, he does not see to embrace it.

Keywords

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

1 Introduction

The short work transmitted with the Aristotelian corpus under the title Περὶ πνεύματος, or *De spiritu*, has not enjoyed much popularity among scholars. In the introduction to his 1913 edition of the text, W. Jaeger called this work "a fruit of an obscure physiologist or a miserable philosopher."[1] W.S. Hett's introduction to the Loeb edition is only slightly gentler, saying that it is a "curious little treatise" featuring "a general lack of coherence in the thought."[2] Influential modern scholars do not hide their dislike of the *De spiritu*: M.C. Nussbaum describes it as a "messy," "confused and inferior late work"; J. Annas calls it a "depressive" and "dismal little work."[3] These are hardly remarks that encourage further reading and studying of the *De spiritu*.

Such remarks, nevertheless, are not surprising. The text is difficult, with numerous lacunas and corruptions. The style is generally unclear and the train of thought often associative, lacking in focus and structure. The intended purpose and audience of the work is unclear. At some places the work is reminiscent of the Peripatetic *Problemata*, piling questions and sketching possible answers, whereas at others it resembles a systematic treatise. The authorship

1 Werner Jaeger, *Aristotelis De animalium motione et De animalium incessu/Ps-Aristotelis De spiritu libellus* (Leipzig, 1913), xviii.

2 Walter S. Hett, *Aristotle: On the Soul, Parva Naturalia, On Breath*, 2nd rev. ed. (Cambridge, Mass., 1957), 484.

3 Martha C. Nussbaum, *Aristotle: De Motu Animalium* (Princeton, 1978), 7, 375; Julia Annas, *The Hellenistic Philosophy of Mind* (Berkeley, 1992), 27.

and dating of the work are also a matter of controversy. Since Jaeger's magisterial study on *pneuma* in the Lyceum, most scholars agree with his verdict that it is a work by an inferior early Hellenistic author with a Peripatetic affiliation.[4] Two recent studies, however – P.J. Macfarlane's unpublished doctoral dissertation from Duquesne University (2007) and the translation and commentary by A.P. Bos and R. Ferwerda (2008) – make valiant attempts to prove that *De spiritu* is a genuine work of Aristotle.[5] The strong focus on the question of authenticity, however, with discussions aiming to show how a particular passage from *De spiritu* is or is not aligned with corresponding passages in Aristotle's authentic works, can easily become a further obstacle to gaining a better understanding of the text.

We propose to approach this treatise on its own merit, as a testimony of questions and concerns that occupied natural philosophers and doctors during a certain period of antiquity. The treatise has already been approached in this way by A. Roselli, who has produced the most authoritative edition of the Greek text to date, accompanied with an introduction, Italian translation, and very helpful notes.[6] However, Roselli provides a piecemeal analysis of the treatise, as behooves that kind of publication, whereas we would like to give a synoptic and coherent presentation of the ideas developed in the treatise, as much as the text allows. Such a presentation should give us a broad understanding of the treatise and a means of tackling its many meanderings, obscurities and contradictions.

Bos and Ferwerda have also aimed to provide a coherent presentation of the ideas developed in *De spiritu*, but we find their underlying hypotheses unconvincing. We do not think, for example, that "there is no position occupied by the author of *De spiritu* that cannot be explained with reference to parts of Aristotle's surviving and generally recognized work."[7] On the contrary, we believe that there are many linguistic and doctrinal differences, some of them quite striking, between Aristotle's recognized treatises and *De spiritu*, which force us to assume that *De spiritu* is not a genuine work of Aristotle.[8] Similarly, we disagree with Bos and Ferwerda that *De spiritu* is mainly a discussion

4 Werner Jaeger, "Das *Pneuma* im Lykeion," *Hermes*, 48 (1913), 61–73.

5 Patrick J. Macfarlane, *A Philosophical Commentary on Aristotle's* De Spiritu (unpublished DPhil thesis, 2007); 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-Boston, 2008).

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

7 Bos and Ferwerda, *Aristotle on the Life-Bearing Spirit*, 22.

8 See Pavel Gregoric and Orly Lewis, "Pseudo-Aristotelian *De spiritu*: A New Case Against Authenticity", *Classical Philology*, 110 (2015), 159–167.

against two pre-Aristotelian theories that place respiration at the heart of all vital processes, one held by Empedocles and Democritus and the other by Plato in the *Timaeus*.[9] Although these pre-Aristotelian philosophers are occasionally the target of criticism in *De spiritu*, and although the author does discuss certain views about respiration, we are convinced that some of these views, as well as other ideas that make an explicit or implicit appearance in *De spiritu*, were formulated after Aristotle.[10]

Of course, we do not pretend that our reconstruction of the anatomical and physiological theory of *De spiritu* is unassailable, and we are aware that we run the risk of finding more coherence in the text than it actually affords. However, as long as our interpretation rests on a few reasonable and mutually consistent hypotheses which are at least partly supported and certainly not contradicted by the text, we believe that we are putting on the table something new and worth discussing.

Our first hypothesis is that *De spiritu* is a unified treatise about *pneuma*, even though the unity seems loose at some places and *pneuma* receives little or no attention in later chapters. The question with which the treatise opens – how the connate *pneuma* is nourished in the body – motivates the first five chapters, where we learn about the author's views on structures he calls *artēriai* and *phlebes* and the processes that take place in them. In the next three chapters, the author's attention turns to two other salient types of structures, namely, bones and *neura* (Chapters 6–8). In Chapter 9 the author explains variations in different types of structures that make up animal bodies, and the central role is assigned to heat or fire. Although *pneuma* is not in the focus of the last four chapters, they add significantly to the picture of *pneuma*'s all-pervasive importance in the body.

Our second hypothesis is that the author operates with a definite, albeit very sketchy, picture of internal human anatomy. More specifically, our hypothesis is that the author takes the view that the body has three distinct, though partially overlapping systems: the system of *artēriai*, the system of *phlebes*, and the system of bones and *neura*. The author has views about the composition and structure of each system, and he assigns distinct functions to each of them. Broadly speaking, the system of bones and *neura* is for support and locomotion, the system of *phlebes* is for nutrition and growth, and the system of *artēriai* is for respiration and perception.

9 Bos and Ferwerda, *Aristotle on the Life-Bearing Spirit*, 23–24.

10 See Orly Lewis and Pavel Gregoric, "The Context of *De Spiritu*," which is also contained in this fascicle of *Early Science and Medicine* 20.2 (2015).

Our third hypothesis is that the author has ideas, some definite and some more tentative, about how each of the systems functions. More precisely, he thinks that the systems contain particular substances, which, owing to their qualities, crucially account for the functioning of the systems. For example, the operative substance in the system of *phlebes* is blood, which is the main agent of nutrition and growth, whereas the operative substance in the system of *artēriai* is *pneuma*, which accounts for several vital activities. We shall also see that *pneuma* is present in the body in another, more fundamental way, whereby it accounts for further salient activities of living bodies.

The structure of our paper is as follows. In Section 2 we give an account of the three systems, their connections, and their composition. In Section 3 we discuss the nature of *pneuma* and its activities in the body. In Section 4 we explain what the connate *pneuma* is, what it does, and how it is nourished. In Section 5 we discuss the relation between *pneuma* and the soul, followed by a general conclusion.

2 The Three Systems

2.1 *System 1: Intake and Distribution of Air*

The first system consists chiefly of a network of hollow structures whose main function is the intake and distribution of air. This system includes the windpipe and the bronchi that extend to the lungs. The author refers to the windpipe as the *artēria* (ἀρτηρία), much like Aristotle and some medical writers.[11] The lungs are connected, most probably through the pulmonary vessels and the heart, with a prominent passage that extends vertically and to which the author also refers as the *artēria*. From the sides of this prominent passage thin channels called *artēriai* (ἀρτηρίαι) branch off and extend along each rib on both sides of the rib-cage.[12] Anatomically, we would identify the prominent passage as the aorta, which is corroborated by the author's view that it pul-

11 E.g. Aristotle, *de An.* II.8, 420b29; "Hippocrates", *Anat.* 1 (Duminil 208,1 = L. 8.538.1), *Morb.* II.53 (Jouanna 190, 3 = L. 7.80.20). Title abbreviations and the editions of treatises attributed to "Hippocrates" can be found at: http//cmg.bbaw.de/online-publications/Hippokrates-Bibliographie_2015_02_19.pdf.

12 483b28–31 (unless otherwise noted, all references are to Roselli's edition – see n. 6 above – and all the translations are our own). See also 483a5–7, where *artēriai* seem to be contrasted with the *artēria*: having stated at 482b17–18 that the *artēria* clearly pulsates at every point, at 483a5–6 the author proposes to consider "whether the air-ducts also pulsate and whether, having the same rhythm <i.e. as the pulse in the heart and in the *artēria*>, [the pulse in the *artēriai*] is also even" (εἰ δὲ καὶ ἐν ταῖς ἀρτηρίαις ὁ σφυγμός, κἂν ὁ αὐτὸς ὢν ἐν ῥυθμῷ καὶ ὁμαλὸς ᾖ, adopting Jaeger's reading).

sates, and its branches would correspond to the intercostal arteries. It is notable that the author does not explicitly mention the connection between this passage and the heart, though he no doubt thinks that some connection does exist, given his view that the pulsating motion of *artēriai* is said to occur in the heart "chiefly and primarily" (482b33–34).

System 1 has another large branch which includes a separate passage that transports inhaled air from some point above the lungs to the stomach (κοιλία) and back out (483a18–22).[13] The author says that the inhaled air cannot be transported there through the esophagus, so he postulates "a passage along the loin" (πόρος παρὰ τὴν ὀσφύν, 483a20–21). We suppose that this passage was required in order to explain the presence of a significant quantity of air moving to and out of the digestive system, and he might have found partial evidence for the existence of such a passage in structures such as the gastric vessels. This branch of System 1 probably includes also the passage mentioned at 484a14 as an *artēria*, through which semen is discharged under compression, admittedly created by *pneuma*.[14] For a diagram of this first System, see Fig. 1.

The flesh and the skin are said to be composed, among other things, of *artēria*, "because they allow the passage of air" (483b17–18). At this and several other occurrences, the term *artēria* seems to refer generically to the structure whose function is to carry air, be this structure microscopic or macroscopic. Indeed, at one point the *artēria* is said to be the only structure receptive of *pneuma* (μόνον δεκτικὸν πνεύματος ἡ ἀρτηρία, 483b18–19).[15] There is no indication that *artēriai* hold blood, and hence we shall speak of these structures as "air-ducts," following W.S. Hett's rendering.

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13 The point of departure of this passage is called βρόγχιον at 483a22, which might be the place where the windpipe branches off into the two primary bronchi. We take it that the passage terminates in the stomach, not in the intestines, which could in principle be meant by the term κοιλία, but the author seems to use a distinct word for the intestines (ἔντερον, 483b24).

14 This *artēria* is probably the ductus deferens. The question "whether the sperm goes through the *artēria* by being compressed, and whether this occurs only in emission" (πότερον δὲ τὸ σπέρμα διὰ τῆς ἀρτηρίας ὡς καὶ συνθλιβόμενον, καὶ ἐν τῇ προέσει μόνον;) is raised at the beginning of Chapter 6, 484a14–15 and immediately left off. We are inclined to agree with Roselli that there is a lacuna following that sentence. The point of the question raised might be whether the compression and consequent evacuation of *pneuma* occurs in this *artēria* only when the semen is emitted, or in other situations too; cf. Aristotle, *Generation of Animals* I.20, 728a9–14.

15 At 485a6–7 the author claims that motor *pneuma* is primarily found in *neura*, which appears to contradict the claim that *artēria* is the only type of structure receptive of *pneuma*. We resolve this contradiction in Section 4.

1= nose and nasopharynx
2= trachea
3= bronchi
4= lungs
5= heart
6= aorta
7= air-ducts extending along the ribs (intercostal arteries)
8= air-duct extending along the loin
9= stomach
10= intestines
11= air-ducts carrying *pneuma* to stomach and the intestines
12= ductus deferens
13= (example of) an air-duct extending to a bone
14= (example of) an air-duct extending to a muscle

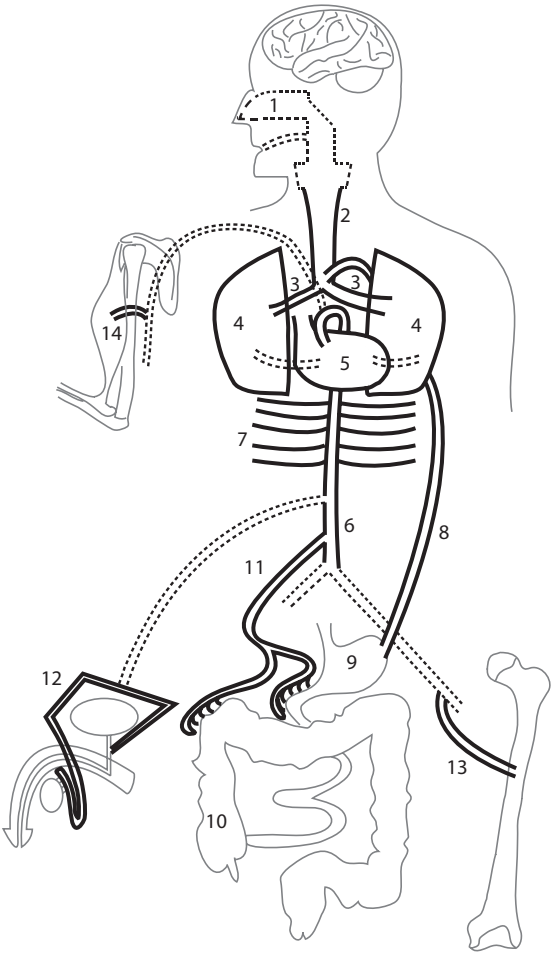

FIGURE 1 *Schematic representation of System 1. Full black lines represent parts of System 1 for which there is explicit textual evidence. Dotted black lines represent presumed passages which connect parts of System 1. Thin grey lines represent salient organs that facilitate understanding of the diagram, some of which are explicitly mentioned in connection with System 1.The diagram represents bodily parts out of their relative sizes and positions for the sake of intelligibility.*

2.2 *System 2: Intake and Distribution of Nutriment*

The second system consists of a network of hollow structures whose main function is the intake of food and drink, its concoction into blood, the distribution of the blood to all parts of the body, as well as the discharge of the residues formed in this process. This system includes the esophagus (στόμαχος) leading

1= mouth and oropharynx
2= esophagus
3= stomach
4= intestines
5= blood-ducts from the *megalē phleps* to the stomach and the intestines
6= liver
7= *megalē phleps* (vena cava)
8= blood-ducts extending along the ribs (intercostal veins)
9= heart
10= (example of) a blood-duct leading to the muscle
11= (example of) a blood-duct leading to the head of a bone
12= (example of) a blood-duct leading to the middle of a bone

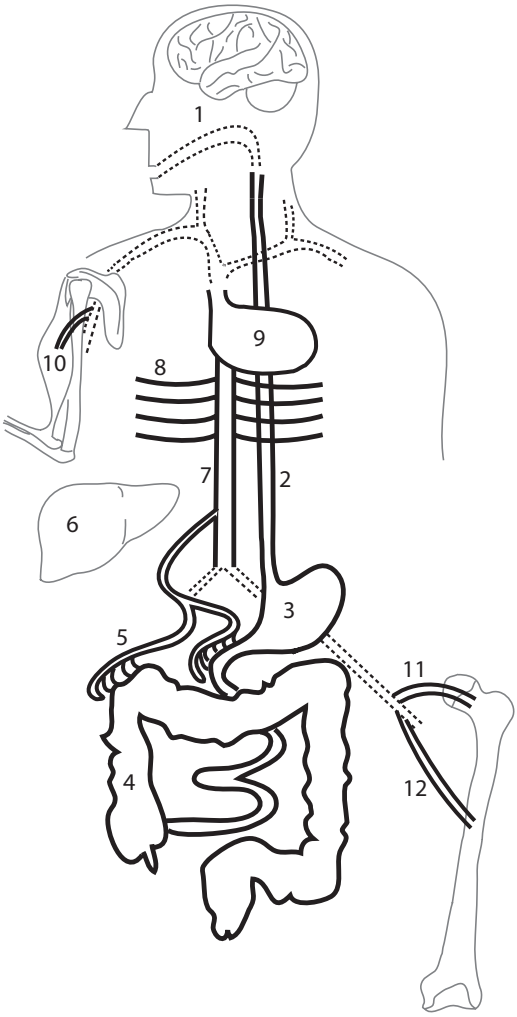

FIGURE 2 *Schematic representation of System 2. Full black lines represent parts of System 2 for which there is explicit textual evidence. Dotted black lines represent presumed passages which connect parts of System 2. Thin grey lines represent salient organs that facilitate understanding of the diagram, some of which are explicitly mentioned in connection with System 2. The diagram represents bodily parts out of their relative sizes and positions for the sake of intelligibility.*

to the stomach and the intestines, as well as a network of passages that carry the blood all over the body, becoming ever smaller as they go through the flesh and reach the surface of the body (483b15–17, 25–27). These passages are called *phlebes* (φλέβες), they are structurally similar to the *artēriai*, and they are said

to be like pipes, delivering their substance through their mouths rather than through their sides (483b27–28).[16]

The most prominent passage in this system is called the *megalē phleps*, which runs parallel with the *artēria* (aorta) and also branches off on both sides into thin ducts which extend along each rib on both sides of the rib-cage (483b28–31*b*). Anatomically, we would identify the *megalē phleps* as the vena cava, which is in line with how this phrase is used in Aristotle and some medical writings.[17] Also, we would identify its branches as the intercostal veins. Again, it is somewhat surprising that the author makes no effort to connect this system with the heart, though he probably assumed that such a connection exists. For a diagram of this second System 2, see Fig. 2.

The flesh and the skin are said to be composed, along with *artēria*, of *phleps*, because in blooded animals flesh and skin bleed when pricked (483b16–17, 484a33–35). At several occurrences, then, the word *phleps* seems to refer generically to the structure whose main function is to carry blood, be this structure microscopic or macroscopic. Hence, we shall speak of such structures as "blood-ducts."

Fresh blood is distributed throughout the body, providing all parts with nourishment and growth (481a10–12, 483b26–28). The dry residue of the transformation of food into blood is discharged through the intestines, which are an integral part of System 2. There is no information on the discharge route of the liquid residue, but presumably the last section of that route, at least in men, is shared by System 1, since the semen emitted by compression through an *artēria* (484a14–15) passes through the urethra which is also used for discharge of urine.

2.3 *System 3: Support and Movement of the Body*

The third system consists of a network of bones and elastic structures called *neura*. The functions of this system are to provide support for the body, to protect the internal organs, and to produce limb movements, especially those movements that enable the animal to go from one place to another.[18]

16 This seems to have been a question of controversy; cf. Erasistratus' claim that *phlebes* deliver nourishment through their sides (Galen, *De fac. nat.* II.7 [Helmreich 177,13–19 = K. 2.105.5–11]).

17 E.g. "Hippocrates", *Anat.* 2 (Duminil 208,11 = L. 8.538.9), who refers to the "so-called *megalē phleps*" (φλὲψ μεγάλη καλευμένη) pointing to a term used by others; cf. *Coac.* 425 (L. 5.680.9), *Epid.* II.5.6 (L. 5.130.3), *Carn.* 9 (Joly 194,11 = L. 8.596.5–6); Aristotle, *Parts of Animals* III.4, 670a17–18; *History of Animals* III.3, 513b1.

18 484b9–13 and *passim* in Chapters 7–8.

The most prominent structure of this system is the spine (ῥάχις), from which the ribs extend on both sides of the trunk to incase the internal organs. The spine is said to have little or no cartilage because it is not meant to be particularly mobile, and the fact that it is relatively stable makes it suitable for an origin of locomotion (484a29–30, b17–20, 37–38). The author considers various possibilities as to how the bones are nourished, and he seems to settle for the view that they are nourished by *neura* (484a30–32).[19]

The author takes *neuron* to be the structure that binds the bones at joints (what we would call ligaments), and also the structure that is attached to the bone at one end and turns into flesh at the other end (what we would call tendons of the skeletal muscles). *Neura* are nourished by mucous fluid, most probably drawn from the flesh which contains air-ducts as well as blood-ducts (484a32–33).

The skin is said to be composed of *neuron*, along with *artēria* and *phleps*, which explains the elasticity of the skin (483b15–17). The statement that there is *neuron* in the heart (484a18) may similarly explain the elastic structure of the cardiac muscle. Sometimes, then, the word *neuron* seems to refer generically to the structure that provides elasticity, be this structure microscopic or macroscopic. *Neura* are said to be very warm and to be the structures in charge of moving the limbs (484a3–5, 485a5–9).

2.4 *The Connections*

Comparing the three systems, we can see that each has a pillar, as it were, supporting the network of kindred structures. The pillar of System 1 is the *artēria* (the aorta), the pillar of System 2 is the *megalē phleps* (vena cava), and the pillar of System 3 is the spine. Interestingly, there is no trace of the idea of a central or pillar-like *neuron* to which all *neura* are ultimately connected. In other words, *neura* do not form a distinct system, but are part of a single system together with the bones.[20] All three pillars are parallel to one another, lying along the vertical axis of the human body.

19 The author considers two options, namely, that *neura* are nourished by the bones (484a15–17, 23–30) and that bones are nourished by *neura* (484a21–23). The author raises difficulties for both options, and they seem indeed to have been a matter of controversy – cf. "Hippocrates", *Loc. hom.* 4 (Joly 43 = L. 6.284). In considering the first option, the author says that blood-ducts and air-ducts manifestly extend to the bones (484a24–26), but he appears to find the second option more satisfactory (484a30–32). If bones are nourished by *neura*, he says, then one must specify what the nourishment of *neura* is, and that poses no problem, since the author confidently asserts the Aristotelian view that *neura* are nourished by the mucous fluid (484a32–33); cf. Aristotle, *History of Animals* III.5, 515b16–18.

20 This aligns the author with Aristotle, and against the Alexandrian doctors who thought

There are three prominent organs lying along the three pillars: the lungs, the heart, and the stomach. The stomach clearly belongs to System 2 because the esophagus leads to it and because blood-ducts are said to be attached to it and to the intestines. Yet the stomach is also connected with System 1 through the "passage along the loin," which brings inhaled air to the stomach. Moreover, it is not only blood-ducts that are said to be attached to the stomach and the intestines, but also air-ducts (483b24–26). So Systems 1 and 2 clearly converge in the stomach and the intestines. Another connection between Systems 1 and 2 is established at 483b28–31*b*:

> From the sides of the *megalē phleps* thin blood-ducts extend along each rib, and likewise from the *artēria*, so that air-duct and blood-duct lie side by side. It is evident to sense-perception that blood-ducts and air-ducts are joined to one another.[21]

The connection between the blood-ducts and air-ducts affirmed here cannot be a direct one, through their mouths, since that is by no means evident to sense-perception. What could be said to be evident to sense-perception, however, is the lengthwise touching of the blood-ducts and air-ducts along the ribs (intercostal veins and arteries), to which the author refers at 483b28–31.[22]

Another thing that one would think is evident to sense-perception is the convergence of the main air-duct (the aorta) and the main blood-duct (vena cava) in the heart, but the author does not make that explicit. There is only implicit evidence that the author thought the heart to be connected to Sys-

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that *neura* form a distinct system stemming from one *archē* (the brain with the spinal chord), which is what we would identify as the nervous system.

21 ἀποτείνειν γὰρ ἐκ τῶν πλαγίων [φλεβῶν] φλέβια λεπτὰ ἐκ τῆς μεγάλης φλεβὸς, καὶ τῆς ἀρτηρίας, παρ᾽ ἑκάστην πλευράν, καὶ ἀρτηρίαν καὶ φλέβα παρακεῖσθαι. τὰς δὲ φλέβας καὶ τὰς ἀρτηρίας συνάπτειν εἰς ἀλλήλας, καὶ τῇ αἰσθήσει φανερὸν εἶναι. We follow Roselli's reading here, with slightly modified punctuation. Roselli transposes here the second sentence (τὰς δὲ φλέβας … εἶναι), which appears in all mss. a few lines down (i.e. following θνήσκειν in 483b35) and is printed as 483b35–484a2 in Bekker's and other editions.

22 The claim that the blood-ducts and air-ducts are connected to one another because "the liquid needs the *pneuma* and the *pneuma* the liquid" (ἐδεῖτο καὶ τὸ ὑγρὸν πνεύματος καὶ τὸ πνεῦμα ὑγροῦ, 484a2–3) may refer to an interchange of qualities through the proximity of the vessels; cf. Aristotle, *On Respiration* 16, 478b17–19; ibid. 21, 480b3–6. Presumably, *pneuma* lends the qualities that are conducive to the maintenance of blood in the right state to effect nourishing of the body. What it receives from the blood in the veins are the qualities of moisture and heat which, as we shall see, are conducive to the maintenance of *pneuma* in the right state to effect its various effects in different parts of the body.

tem 1 – the pulsation of the air-ducts which originates in the heart – and virtually no evidence that he thought the heart to be connected to System 2. At 482b29–34 the author mentions the Aristotelian view that the nutritive liquid is heated in the heart, causing the *pneuma* trapped in the liquid to be released, which brings about pulsation. If the nutritive liquid is indeed in the heart, it must have got there through System 2. More generally, it is difficult to imagine how he could fail to be aware of the entry of the vena cava into the heart, either by direct observation or from the testimonies of the so-called Hippocratic doctors and Aristotle. A further conjecture that we have to make about the heart is that it is connected with the lungs, most likely through the pulmonary vessels, though the grounds for this conjecture will become clear later.

It is curious that the heart is mentioned only five times in *De spiritu*, with reference to the origin of pulsation and to the *neura* that it contains (482b6, 33, 483a16, 484a18, 485a8). The liver is mentioned only once, in a cryptic passage asserting that it has no air-ducts (484a12). If the remark is intended with the implication that the liver has only blood-ducts, the author probably has in mind the view that the liver plays a role in the production of blood.[23] This would mean that the author believed that the nutritive material originating in the stomach and distributed by the blood-ducts passes through the liver, and in some way gets processed there before entering the main blood-duct (the *megalē phleps*) and its branches. The brain is mentioned twice, but in the same immediate context, as a structure enveloped and protected by the skull, exemplifying the protective function of the bones.[24] There is nothing about the brain's function or its connection with *neura*, air-ducts or blood-ducts. Finally, the kidneys and the bladder are not mentioned at all.[25]

The claim that there are *neura* in the heart (484a18, 485a8), which is familiar from Aristotle,[26] establishes some sort of connection of the heart with System 3. The context of 485a8 strongly suggests that the presence of *neura* in the

23 On the liver as the source of all or one of the main *phlebes*, see "Hippocrates", *Alim.* 31 (Joly 144 = L. 9.110), *Oss.* 7 (Duminil 143,14–15 = L. 9.172.14–15); Galen, *PHP* VI.3.5–42 (De Lacy 372–382 = K. 5.520–532). Erasistratus and Galen awarded it the role of blood production (Galen, *PHP* VI.6.12–13, 6.21, 8.2–36 [De Lacy 398, 408–414 = K. 5.550, 552, 564–572]).

24 484b16–16*a* (following Roselli, who prints the relevant part of 483b21 in l. 16*a*). Admittedly, the author mentions that some hold the brain, as opposed to the marrow, to be the *archē* of motion, but the author himself is not at all concerned with this question or with the role of the brain in general, but only with the role of the bones which protect it.

25 Apart from the air-ducts, blood-ducts and *neura*, there are further structures in the body called ἀγγεῖα (e.g. 481a30, 481b6). It is unclear what these structures are, or how they are connected to the three systems.

26 Aristotle, *Parts of Animals* III.4, 666b13–14 and *History of Animals* III.5, 515a28–29.

heart accounts for the heart's motion, that is, for its pulsation. System 3 is connected to Systems 1 and 2 insofar as some *neura* are said at 484a19–20 to be extensions of the flesh (tendons of skeletal muscles), and flesh is said to contain air-ducts and blood-ducts. The three systems overlap also in the skin, which is said to contain all three structures: air-ducts, blood-ducts, and *neura* (483b15–16). Finally, at 483b31*b*-33 the author suggests that the bones are connected not only by *neura* but also by blood-ducts, "both in the middle and in the articulations of their heads," later adding that air-ducts also visibly extend to the bones (484a24–26).

The multiple connections of the three systems clearly show that they are not isolated or separable from one another, but closely integrated parts of a functional animal body.

2.5 *The Composition of the Three Systems*

The composition of the main types of structures organized into the three systems is explained in Chapter 9, which is devoted to explaining the anatomical diversity of parts within a single body, but also among bodies of different animal species. Parts of the body – such as bones, flesh, air-ducts, blood-ducts and *neura* – are all made of simple bodies (τὰ ἁπλά, 485b19, 22) mixed in different ratios. The difference in ratio accounts not only for the difference in qualities, shapes and dimensions of various types of structures (e.g., the difference between bones and *neura*), but also for the diversity within the same type of structure, whether in the same body (e.g., softer and harder bones), or in the bodies of different species (e.g., the bones of humans and the bones of lions).[27]

The only two components of mixtures that the author specifies are heat/fire and *pneuma* (485b10).[28] Other components, presumably the remaining simple bodies – earth and water – are implied by the author's reference to the "other simple bodies," in plural (τῶν ἄλλων ἁπλῶν, 485b19). We take it that *pneuma* and especially heat/fire are singled out because they are thought to be more important than the other simple bodies, as they contribute more than the other simple bodies to the constitution of bodily structures.

Nature is said to assign (ἀποδιδόναι) properties to the structures by determining the ratio of mixture of their components (485b7–11). Heat/fire has the instrumental role in this process, as it brings about the qualities, shapes and dimensions of the structures required by nature, much like fire in the oven brings about the quality, shape and size of the metal required by the blacksmith (485a29–486a4). The role of *pneuma* in this context is not explicated,

27 485b20–486b4.

28 The author appears to use fire and heat interchangeably.

but we suppose it is to secure the right balance of heat in the mixture, preventing it from both dwindling and from becoming too intense.

At any rate, it is clear that all parts of the body contain heat and *pneuma*, and that different ratios of their mixing with the other simple bodies are responsible for the constitution of different structures that make up the three systems. We shall argue in Section 4 that this *pneuma* at the level of composition is what the author calls "connate *pneuma*."

3 *Pneuma*

The author distinguishes between external or atmospheric air, which he tends to call ἀήρ, and internal air, which is a portion of external air that is inhaled and distributed inside the body; the latter he tends to call *pneuma* (πνεῦμα), much like Aristotle and medical authors before him. From the moment a portion of inhaled air enters the body, it undergoes alteration: it becomes condensed, it receives moisture from the hollows and walls of the windpipe and bronchi (483b6–9, 22–23), and it becomes warmer. These qualitative changes, achieved simply by means of passing through the right passages, turn air into *pneuma*. Indeed, the author says that "the external air is mild, whereas once it is enclosed [inside the body] it becomes *pneuma*, as it gets condensed and distributed somehow."[29] This does not involve transformation of one substance into another, as when the ingested food undergoes the process of concoction and becomes blood and residues. It is only that the inhaled air, by acquiring the aforementioned qualities as it passes through the body, and by achieving various effects in different parts of the body, deserves a distinct appellation. Although the author is not always consistent in maintaining the terminological distinction between external air (ἀήρ) and air inside the body (πνεῦμα), the conceptual distinction owing to their different physical qualities and effects seems to be clear.[30]

One portion of inhaled air goes through the windpipe and the bronchi into the lungs, whereas another portion goes through the "passage along the loin" to the stomach, where it contributes to the digestive process. It is not entirely clear how *pneuma* contributes to the digestive process in the stomach, but admittedly it has some qualities which are necessary for the production of the nutritive liquid that will be turned into blood. We suggest that this is not, or at any rate not primarily, the quality of coldness conducive to thermal regulation,

29 483b6–8: ἔξω μὲν γὰρ πραῦς, ἐμπεριληφθεὶς δὲ πνεῦμα, καθάπερ πυκνωθεὶς καὶ διαδοθείς πως.

30 See 481a14, 29, b22, 482a5.

but rather some quality conducive to the process of concoction itself.[31] As for the portion of air which goes into the lungs, its main function is thermal regulation of the upper parts of the body (482a31–32), presumably owing to the heat generated by the heart and stomach.

It is difficult to say what exactly the author thinks happens with the inhaled air after it arrives in the lungs and achieves the cooling effect. Admittedly, most of this *pneuma*, being heated and no longer useful for thermal regulation, is expelled through exhalation. However, a portion of this *pneuma* seems to remain in the lungs from where it gets distributed all over the body through the system of air-ducts (482a32–34). We do not know what happens with this portion of *pneuma*, save that it does not undergo concoction – neither in the lungs themselves, as Aristogenes had thought (481a28–30), nor in the structures through which it is distributed to the rest of the body, as some unnamed people had maintained (481b12–15) – that much the author made clear in Chapter 2. We can only speculate whether the portion of the heated *pneuma* in the lungs that is not expelled with exhalation acquires some further qualities before it becomes suitable for distribution around the body. We shall return to this question in the next section.

In Chapter 4 the author lists three distinct types of motion of *pneuma* in the air-duct: (a) respiratory motion (ἀναπνοή), (b) digestive motion (ἡ θρεπτικὴ κίνησις), and (c) pulsating motion (σφυγμός).

(a) The respiratory motion, we take it, refers to the intake of air through the mouth or nose, its passing through the windpipe and the bronchi and arriving in the lungs, where it achieves cooling. Of course, inhalation is immediately followed by exhalation, the process of evacuating the *pneuma* used for the purpose of cooling. The process of evacuation takes place in the same structures, in reverse direction. We have suggested that not all of the heated *pneuma* in the lungs is exhaled, but that one portion remains to be distributed throughout the body.

(b) As for the digestive motion of *pneuma*, we have shown that a portion of inhaled air, before it reaches the lungs, goes from the bronchi to the stomach through a "passage along the loin," where it contributes to the concoction of food. The surplus of *pneuma* in that process is evacuated through the same route, referring most probably to the familiar phenomenon of belching.[32] These motions take place in System 1 – in the windpipe and the "passage along

31 At 481a14–15 the author mentions the possibility that air is productive of the activity of concoction.

32 We take it that the remark at 483a23 "this is obvious to sense-perception" (τοῦτο δὲ τῇ αἰσθήσει φανερόν) does not refer to the existence of the postulated passage along the loin,

the loin" – and they are most probably what the author had in mind when he spoke of the digestive motion of *pneuma* in *artēria*. However, some digestive motion of *pneuma* probably takes place also in System 2. So, for instance, a portion of air may help to introduce food and drink into the body and be swallowed with them, arriving at the stomach through the esophagus. Presumably, the author thought that this portion of air does not suffice for the process of concoction of food in the stomach, which is why he postulated the passage along the loin and the digestive motion of *pneuma* in the *artēria*. Furthermore, it is likely that the author thought that *pneuma* acts to expel the residues – dry residue through the intestines and liquid residue through the urethra. All such motions of *pneuma*, we take it, "introduce and process nourishment" (ἡ τὴν τροφὴν ἐπάγουσα καὶ κατεργαζομένη <*scil.* κίνησις>, 482b15–16).

(c) The third type of motion of *pneuma* in the *artēria*, pulsation, is supposed to be "obvious to perception at whichever part one touches" (ἡ μὲν τοῦ σφυγμοῦ <*scil.* κίνησις> καὶ τῇ αἰσθήσει φανερὰ καθ' ὁτιοῦν μέρος ἁπτομένοις, 482b17–18). The author argues that it occurs primarily in the heart, spreading to the *artēria* (windpipe and aorta) and the *artēriai* (all branches of the aorta) and getting increasingly weaker or slower as the air-ducts become smaller at the periphery (482b33–34, 483a5–7, 15–16). The author says that the pulsating motion appears to be accidental (482b29–30), a mere byproduct of the release of the *pneuma* trapped in the nutritive liquid as it undergoes the process of cooking, which is Aristotle's position.[33] However, the author distances himself from Aristotle's position:

> 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*.[34]

So our author thinks, against Aristotle, that the pulsating motion of *pneuma* has a definite function, although he is uncertain what it is. In addition, our author is eager to show that pulsation is temporally prior to the respiratory and nutritive motions of *pneuma*, and in particular that pulsation is not dependent on respiration, and this priority seems to lend additional support to his view

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but to the fact that there is a portion of inhaled air that goes into the stomach and back out (καὶ πάλιν ἔξω, 483a22).

33 Aristotle, *On Respiration* 20, 479b26–480a15.

34 483a17–18: καὶ <*scil.* ὁ σφυγμός> ἔοικεν ἐνεργείᾳ τινὶ καὶ οὐκ ἐναπολήψει πνεύματος, εἰ μὴ ἄρα τοῦτο πρὸς τὴν ἐνέργειαν.

that the pulsating motion must be quite important, though he is unable to say why.

To conclude this section, we have seen that inhaled air becomes *pneuma* as soon as it enters the body, where it acquires certain qualities such as density, moisture, and heat. It enters the body through respiration and takes different routes, achieving different effects in different structures. On its route to the lungs, it effects cooling (the respiratory motion of *pneuma*). On its route to and inside the stomach, *pneuma* aids the concoction of food and the evacuation of residues (the digestive motion of *pneuma*). In the heart and the system of air-ducts extending beyond the lungs, *pneuma* has the pulsating motion. We are inclined to think that the purpose of pulsation is to help distribute around the body the portion of heated *pneuma* which is not immediately exhaled from the lungs, though the author does not say so.[35] At any rate, whether this portion of *pneuma* is distributed by pulsation or by respiration, the author clearly thinks that it is distributed from the lungs to the rest of the body through the system of air-ducts and that this does not happen for the sake of cooling (482a34-b2). In the next section we argue that this happens for the sake of nourishing the connate *pneuma* throughout the body, and it is to this type of *pneuma* that we now turn.

4 The Connate *Pneuma*

The author of *De spiritu* does not explain what he means by the connate *pneuma*. The fact that a portion of *pneuma* is called "innate" (ἔμφυτον) or "connate" (σύμφυτον) suggests that it is not acquired from the outside, whether through respiration or digestion, but rather, that it is somehow intrinsic to the body. That is a familiar Aristotelian idea. More to the point, the author seems to take it for granted that the connate *pneuma* is the source of strength in the body, which is another familiar Aristotelian idea.[36] The author also takes it for grant-

35 This seems to have been the view of physicians such as Praxagoras of Cos and Herophilus of Chalcedon see: Galen, *PHP* VI.7.1–8 (De Lacy 404–406 = K. 5.560–562 = fr. 28(b) in Fritz Steckerl, *The Fragments of Praxagoras of Cos and his School* [Leiden, 1958]); *De diff. puls.* IV.6 (K. 8.733 = fr. 144 in Heinrich von Staden, *Herophilus. The Art of Medicine in Early Alexandria* [Cambridge, 1989]), cf. 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), 271, 294–295, 304–305, 357.

36 See Aristotle, *Movement of Animals* 10, 703a8–10; *On Sleep and Waking* 2, 456a15–16; *Generation of Animals* II.4, 737b32–738a1 and V.7, 787b10–788a16. One might object that ἰσχυρότερον at 481a2 does not really say that the *body* grows stronger by means of the

ed that the connate *pneuma* requires nourishment (τροφή, 482a8, 27). This is a perfectly reasonable assumption: if the connate *pneuma* is a part of the body, it must be subject to change and waste, and hence in need of constant replenishment. Moreover, as the body matures and grows larger, more strength is required in order to move the limbs; if the connate *pneuma* is the source of strength in the body, it also must grow in bulk, in order to provide more strength to the growing body. So the author naturally wonders what the source of nourishment of the connate *pneuma* actually is. There seem to be only two possibilities – digestion and respiration – and his discussion in Chapters 2 and 3 shows that neither possibility is unproblematic.

What we know is that the author thinks that the connate *pneuma* pervades the whole body (δι' ὅλου, 481b19, 482a33) and that it originates from the lungs (ἀρχὴ ἀπὸ τοῦ πνεύμονος, 482a34).[37] We propose to make sense of the author's position by making two assumptions. First, that the connate *pneuma* refers to one of the simple components from which all parts of the body are made, namely, the component explicitly specified as *pneuma* and closely associated with heat/fire in Chapter 9, as outlined in Section 2.5 above. This *pneuma* is indeed intrinsic to the body: it is there from the moment of conception and it grows together with the body (literally, συν-φύειν).

The second assumption is that the connate *pneuma* is nourished by the portion of *pneuma* that remains in the lungs from the process of respiration and which is distributed around the body through the system of air-ducts. We have proposed in Section 3 that when we inhale, a portion of air goes to the lungs for the sake of cooling. This *pneuma* is heated in the lungs and most of it is exhaled to make room for a fresh breath, but a portion remains in the lungs. We do not know what exactly happens in the lungs, whether this portion of *pneuma* is only heated, purified or otherwise altered; but that portion of air, we would argue, is distributed throughout the body through the system of air-ducts – more precisely, through the pillar of System 1 (the aorta) and its increasingly smaller branches that reach almost every corner of the body – possibly with the help of pulsation.

So when the author says at 482a34 that the connate *pneuma* "originates from the lungs," we take him to mean that *pneuma* with all the right qualities is

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connate *pneuma*, but rather that the connate *pneuma* grows stronger (ἰσχυρότερον). This is a less precise way, we take it, of expressing the same idea. This idea is corroborated by what we say about the role of the connate *pneuma* in the movement of limbs.

37 With this, we believe, the author goes beyond Aristotle, since it is not clear that Aristotle thought the connate *pneuma* pervaded the whole body, and he almost certainly thought that it originated from the heart; see Aristotle, *Movement of Animals* 10, 703a11–16.

produced in the lungs and distributed from them to the rest of the body for the purpose of nourishing the connate *pneuma*. In other words, the connate *pneuma* – from which different parts of the body are composed in different ratios of mixture with heat/fire and the other simple components – is nourished by the *pneuma* produced in and distributed from the lungs. And the *pneuma* produced in and distributed from the lungs, we have argued, is the portion of heated *pneuma* that is not exhaled.

If we are right about this, it follows that the connate *pneuma* is nourished, ultimately, through respiration. To be sure, the author does not say so, and in Chapters 1 and 2 both possible sources of nourishment of the connate *pneuma* – digestion and respiration – are found problematic. However, in Chapter 3 we learn that, although respiration proper is for cooling the upper parts of the body (482a31–33, a36-b2), "breath is continuously distributed to all the parts (…) and it would be strange if they did not need some motion and a sort of nourishment. And if it breathes through the whole body, it is no longer for the purpose of cooling."[38] We understand this to mean that the connate *pneuma* from which all parts of the body are constituted, upper as well as lower, requires nourishment, and that this nourishment comes from respiration. So the author is committed to the view that the connate *pneuma* is, after all, nourished by respiration, though he hesitates to say so straightforwardly.

He hesitates for at least two reasons. One is that there are animals which do not breathe, or otherwise take in air from the outside, such as aquatic animals, so their connate *pneuma* certainly cannot be nourished by respiration (482a7–26).[39] The other is that even in animals which do breathe, the connate *pneuma* is not nourished by respiration as such; rather, it is nourished by respiration in conjunction with the process of digestion that generates a lot of heat in the upper parts of the body, and probably also in conjunction with the process of pulsation that facilitates the distribution of the nourishment of the connate *pneuma* from the lungs to the rest of the body. Without these two complementary processes, we think, respiration would not suffice for the task of nourishing the connate *pneuma*, which might be what prevented the author from stating bluntly that the connate *pneuma* is nourished by respiration.

38 482a34-b2: (…) τὸ τῆς ἀναπνοῆς εἰς πάντα διαδίδοσθαι κατὰ συνέχειαν (…) ἄτοπον δὲ εἰ μὴ δεῖταί τινος κινήσεως καὶ οἷον τροφῆς. εἰ δὲ διαπνεῖ πρὸς πᾶν, οὐκ <ἂν> ἔτι καταψύξεως εἵνη χάριν. We shall presently argue that κίνησίς τις at 482b36 refers to the effect of the connate *pneuma* in the system of *neura*, which explains movements of the limbs.

39 In one passage, however, the author suggests that fish breathe, after all: 483b33–35; cf. Roselli's note *ad loc.*

Now the connate *pneuma* in two distinct types of structures seems to have two distinct effects that are worth mentioning. In Chapter 5 we learn that the air-duct is the only type of structure which perceives (ἡ ἀρτηρία μόνον αἰσθάνεται, 483a24), and the author wonders whether this is due to the *pneuma* that goes through the air-duct, or to the air-duct itself.[40] Without clearly opting for either option, the author turns to the possibility that the ordinary air is perceptive. This seems to render the soul superfluous, whereas the author thinks that the soul should rather be considered as the cause of perception (483a27–28). Unfortunately, it is hard to make sense of the rest of the passage, due to the poor state of the text and to the author's aporetic style; he raises several opposing options concerning the air's relationship with the soul, leaving his preferred view unclear (483a30–36).

We are inclined to think that it is not the *pneuma* percolating through the system of air-ducts that renders the animal body sensitive, but rather the air-ducts themselves, or more precisely, the connate *pneuma* from which the air-ducts are composed and which is nourished by *pneuma* transported from the lungs. Our main evidence for thinking so is the author's claim that the soul is present in *pneuma* and fire (485b11–12), referring to the components of bodily parts. One might wonder, of course, why the air-duct is the only type of structure which is sensitive, although the connate *pneuma* is found in other parts of the body, too. A plausible reply would be that this is because the connate *pneuma* is mixed with heat/fire and the other simple components in the right way to afford perception in that type of structure and no other.

There is a similar situation, we suggest, with the presence of *pneuma* in *neura*. *Neuron* is introduced for the first time at 483b13, where the author asserts that air-duct is the only type of structure receptive of *pneuma*, "whereas *neuron* is not." However, at 485a7 the author claims that "motor *pneuma* is primarily in *neura*." We propose to solve this apparent contradiction by assuming that the air-duct is the only type of structure through which *pneuma* percolates, whereas *neura* are not hollow structures through which *pneuma* could travel, as Herophilus and Erasistratus thought, but a warm and elastic type of structure attached to the bones, as Aristotle thought. *Pneuma* can be present in

40 Compare Aristotle's discussion of whether it is blood or the parts containing blood which perceive (*Parts of Animals* II.10, 656b19–22; III.4, 666a16–18). In the current passage the alternatives actually formulated are: "by the *pneuma* which runs through the air-duct, by the bulk, or by the body" (πότερα τῷ πνεύματι τῷ δι᾽αὐτης, ἢ τῷ ὄγκῳ, ἢ τῷ σώματι, 483a24–25). It is difficult to say whether and how the latter two alternatives differ, but presumably the last alternative, at least, refers to the bodily composition of the air-duct itself. Roselli suggests that ἢ τῷ σώματι is a gloss.

such a structure only at the level of composition, where it mixes with heat/fire and the other simple components in the right ratio which allows *neura* to effect locomotion. We do not know how the author envisioned *neura* to effect locomotion, but perhaps he thought that one set of *neura* contracts, possibly as a result of decreased heat in them, thereby pulling the bones to which they are attached, while another set of *neura* relaxes, possibly as a result of an increase in heat, allowing the bones to be moved.[41]

So the motor *pneuma* in *neura*, on our account, is the connate *pneuma* of which *neura* are composed, not a substance that travels through *neura*, as the Alexandrian doctors maintained. Unfortunately, the text does not say anything as to how the motor *pneuma* in *neura* produces locomotion, much less how it does so in a guided and purposeful way.

5 *Pneuma* and Soul

At several places in the treatise *pneuma* is closely associated with soul (481a15–19, 483a27–35, 483b8–12). This is not surprising, given that *pneuma*, in various states and places in the body, is involved in many functions characteristic of the animal body. It effects cooling through respiration, assists digestion, percolates through the system of air-ducts (possibly by means of pulsation), enables perception, and effects locomotion. We have argued that perception and locomotion are not effected by percolation of *pneuma* through air-ducts and *neura* respectively, but by the connate *pneuma*, that is, in our reconstruction, the airy component of various structures in the body. The tiny air-ducts in the flesh and skin contain the airy component which is mixed in just the right ratio with heat/fire and the other simple components of air-ducts to make the animal sensitive to touch. Similarly, *neura* can produce locomotion, presumably by contracting so as to pull the bones, because the airy component is mixed in just the right ratio with heat/fire and the other simple components of *neura*.

So *pneuma* seems to play a role of a versatile instrument by means of which different functions are executed. However, *pneuma* plays this role in some cases as an airy substance that percolates through *artēriai* and in others as a material component of *artēriai* and *neura*. In Chapter 9, 485b6–7, the author

41 The author claims that heat in *neura* is more intense than in other types of structures (484a3–5). Aristotle also connected the workings of *neura* with thermal changes in the heart; see *Movement of Animals* 7, 701b2–16; 8, 701b33–702a2. See Pavel Gregoric and Martin Kuhar, "Aristotle's Physiology of Animal Motion: On *Neura* and Muscles," *Apeiron*, 47.1 (2014), 94–115 for Aristotle's account of *neura* and the way they produce locomotion.

describes heat/fire as both an instrument and as matter, and it is reasonable to suppose that the same description, in our author's mind, holds of *pneuma* too. After all, at 485b10 fire and *pneuma* are mentioned in conjunction, and we have argued that these are two salient components that mix in various ratios with other simple bodies to form different bodily parts. Apparently, the author does not find it problematic to suggest that the same thing, such as fire and *pneuma*, can be used both as an instrument and as matter (485b7–9).

What he finds problematic, rather, is how nature, which uses fire and *pneuma*, could itself manifest such intelligence as is necessary to mix the components of bodily parts so as to adorn them with just the right qualities, shapes and dimensions.[42] The same problem is then extended to soul (τοῦτο θαυμαστὸν [ταὐτὸν] καὶ περὶ ψυχῆς, 485b11–12), which suggests quite strongly that the author does not follow Aristotle in thinking that soul is the nature of a living being.[43] Had the author followed Aristotle and regarded soul or nature as a formal cause, i.e., as something that explains shape and organization of matter, this problem would not have arisen. The fact, however, that the problem does arise for our author, indicates that he does not fully understand or embrace formal causation, which explains why he can only wonder at the works of nature and its "demiurgic" agency in Chapter 9 (cf. 485b13 and 36).

Of course, if soul is not a formal cause, our author's conception of soul and his idea of the relationship between soul and *pneuma* must differ significantly from Aristotle's. Indeed, the author claims that soul is present in heat/fire and *pneuma* (ἐν τούτοις γὰρ ὑπάρχει, 485b12, referring back to πυρὸς καὶ πνεύματος in l. 10), i.e., in certain components of bodily parts, rather than in the whole natural body equipped with parts of requisite properties and organization for enabling the living being to engage in the activities typical for its kind, as Aristotle thought. More specifically, it is *pneuma* that is said to be "the primary receptacle of soul" (τὸ πρῶτον δεκτικὸν ψυχῆς, 483b10–11). The author seems to understand this relation between soul and *pneuma* as implying that soul and its receptacle must have a matching degree of fineness and purity. This relation is anticipated already in Chapter 1, at 481a17, where the author speaks of *pneuma* being "naturally conjoined" with soul on account of its high degree of

42 485b7–11. For the word ῥυθμός in l. 9, see Roselli *ad loc*.

43 It is not clear how the author conceived of the distinction between nature and soul. Perhaps he thought that nature operates at the level of composition of bodily parts, and soul at the level of the organism constituted of all the bodily parts. It is not excluded that he thought, like the Stoics Herophilus and Erasistratus, that nature accounts for the vegetative processes such as cooling, digestion and pulsation, while soul accounts for the characteristically animal processes, such as perception and locomotion. The author's conception of soul and its relation to nature and *pneuma* requires a separate study.

pureness (καθαρώτερον γὰρ ὃ τῇ ψυχῇ συμφυές, 481a17). In such a relation, soul seems to be conceived along materialist lines.

On the other hand, the author seems to be well aware of Aristotle's conception of soul. For instance, he insists that soul is a *dunamis* (483a27, 34). Moreover, at 483a27–29 he appears to lean towards the Aristotelian view that soul's *dunameis* are prior to, or conditions of, the corresponding actions of *pneuma* in the body, in contrast with the more reductionist view that soul's *dunameis* are identical with the actions of *pneuma* in the body. At 483a25–27 he argues that air itself could never achieve perception; what is required is soul as the cause of the right sort of motions in the body, and presumably, at a lower level, nature as the cause of the composition and articulation of parts in which motions of the right sort take place.[44]

We have seen that *pneuma* is involved in carrying out vital activities such as digestion and respiration, as well as in higher activities such as perception and locomotion. It is surprising, however, that nothing is said about *pneuma*'s involvement in reproduction, one of the most salient animal functions and one in which *pneuma* figures prominently in Aristotle's theory and in earlier medical thought. The only indication in that direction is the disconnected question at the beginning of Chapter 6 (484a14–15), as to whether the semen goes through the air-duct by being compressed, where the compression is probably effected by *pneuma*. It is possible, however, that the role of *pneuma* in reproduction was discussed in a lost chunk of text following the question.[45]

6 Conclusion

Towards the end of *Generation of Animals* Aristotle wrote:

> It is reasonable that *pneuma* is used as an instrument in many cases. Just as some things have many uses in arts, e.g., the hammer and anvil in the blacksmith's art, so does the *pneuma* in things constituted by nature.[46]

44 See Section 2.5 above.

45 See n. 14 above. Roselli indicates a lacuna following the question at 484a14–15, which seems correct.

46 Aristotle, *Generation of Animals* v.8, 789b8–12: τὸ τῷ πνεύματι ἐργάζεσθαι τὰ πολλὰ εἰκὸς ὡς ὀργάνῳ· οἷον γὰρ ἔνια πολύχρηστά ἐστι τῶν περὶ τὰς τέχνας, ὥσπερ ἐν τῇ χαλκευτικῇ ἡ σφύρα καὶ ὁ ἄκμων, οὕτω καὶ τὸ πνεῦμα ἐν τοῖς φύσει συνεστῶσιν.

It seems as if the *De spiritu* is an attempt to spell out more fully the ways in which *pneuma* is instrumental to various animal activities, and we have tried to reconstruct the author's theory. We have suggested that the author's theory has several levels, and *pneuma* is crucial to all of them. At the most basic level of composition, the connate *pneuma* is the key component of structures that make up the body. As *pneuma* mixes with other simple components in different ratios, it determines the characteristics of these structures and their functions, such as perception and locomotion. At a higher level, the level of distinct systems, *pneuma* percolates through the hollow structures, achieving different effects in them, notably cooling in the lungs, assisting digestion in the stomach and the intestines, but also nourishing the connate *pneuma* in the rest of the body.

While the Aristotelian context of the work cannot be ignored, we do not wish to suggest that the treatise *De spiritu* was written by Aristotle. We are quite certain, for many reasons, that it was not. One of the reasons, as we have just seen, is that the author does not operate with the Aristotelian conception of soul as a formal cause. However, we do think that the author was inspired by Aristotelian ideas, picked up some loose ends that Aristotle had left underdeveloped, and tried to build an Aristotelian theory of anatomy and physiology with *pneuma* in the central role. Of course, this was not the only framework shaping our author's efforts. The questions he raises and the answers he puts forward point also to the early Hellenistic context of his discussion, in so far that the author attempts to refute or incorporate theories in circulation at the time. While the current paper has focused on the substance of his attempts, the examination of the context of *De spiritu* and its contribution to our understanding of the history of anatomical and physiological ideas in the first half of the third century BC is pursued in a separate paper, published in this same fascicle of *Early Science and Medicine*.

Unfortunately, the author often presents his ideas in a confused and unstructured manner, which makes every reconstruction of his theory difficult and largely tentative. This paper presents a reconstruction based on a few reasonable hypotheses and assumptions that are anchored in the text, or at any rate not incompatible with the text, yielding an encompassing interpretation of this difficult treatise. As such, the paper does not aspire to be the last word on the substance of *De spiritu*, but to encourage further research.