

The Physiology of *Pneuma* and the Relationship between Aristotle and Greek Medicine

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Abstract

Aristotle's 'innate *pneuma*' (σύμφυτον πνεῦμα) has repeatedly been interpreted as if it were a particular element that has transcended the physical phase of material transformations. The purpose of this paper is to question this way of thinking and to recapture an understanding of *pneuma* above all as a 'substance' that plays an essential role in physiological processes, while also functioning in normal physical processes.

This paper contradicts standard interpretations of Aristotle's theory of *pneuma* and defends a new concept of hylomorphic and perceptual theories and simultaneously establishes a firm ground for an interpretation of *pneuma* on the level of sense perception and thought, based on nutrient intake with accompanying material changes.

Keywords: Aristotle, *Pneuma*, *De generatione animalium*, Hippocrates, Greek Medicine

Introduction¹

Aristotle's 'innate *pneuma*' (σύμφυτον πνεῦμα) has repeatedly been interpreted as if it were a particular element that has transcended the physical phase of material transformations.² The purpose of this paper is to question this way of thinking and to recapture an understanding of *pneuma* above all as a 'substance' that plays an essential role in physiological processes, while also functioning in normal physical processes. One major challenge we face is the re-examination of the relationships between the 'innate *pneuma*' and the proximate entities of 'aether' and 'life heat'. Clarifying the ideological interchange between *pneuma* theory, as posited in Aristotle's *De generatione animalium* and Greek medical thought, will shed new light on this problem.³

1. Identifying the Problem: *Pneuma* as the Soul and Aristotle's Philosophy of Physiology

Of the pre-Socratic philosophers, it was

Anaximenes who first referred to *pneuma*, linking it to the soul. According to Anaximenes, the origin (ἀρχή) of all things is air (ἀήρ): 'Our soul (ψυχή) is air, and as it supervises us, the whole cosmos is composed of *pneuma* and air' (DK13B2).⁴ The soul was thought to come into the body through the intake of breath (= *pneuma*), and therefore the *pneuma*, which means 'breath, air, wind. etc.', was thought to be life itself and to mediate communication between the microcosmos and the macrocosmos. Indeed, linking the soul to *pneuma* was quite common in ancient Greece.⁵ For example, Diogenes of Apollonia says, '*pneuma* is soul, it is intelligence' (DK64B4).

However, Aristotle has a unique understanding of *pneuma*: his theory of the soul places *pneuma* within his theoretical framework of matter and form. Aristotle describes 'innate *pneuma*' as being born to life (σύμφυτον), distinct from the external air. That is, humans have some intrinsic aspect of life distinct from the 'outside *pneuma*' (ἐπίσακτον πνεῦμα) that enters the body by breathing (cf. *De partibus animalium*, 659b19). Aristotle describes this 'innate *pneuma*' as a result of the 'hot air' (θερμὸς ἀήρ) in sperm

(semen [σπέρμα] and seed [γονή]),⁶ which he understands as having the role of converting the soul from form to matter (menstrual blood) (*De generatione animalium*, II 736alff.). In addition, Aristotle argues that ‘innate *pneuma*’ explains the movement of animals through its connecting of the soul’s mental state, or desire (ὄρεξις), and the body’s physical state (*De motu animalium*, 6-11). Based on these references, contemporary scholars claim that ‘innate *pneuma*’ can be understood through the theory of hylomorphism as a medium for perceptual function.⁷

Most scholars focus their interpretations of Aristotle’s thoughts on the material or physical foundations for this perceptual function in his work *De anima*. Some scholars interpret Aristotle from a functionalist standpoint, acknowledging causal linkages between mental and physical states, but arguing that the mental state cannot be necessarily reduced to the physical one.⁸ Some, however, object to this position, pointing out that such an interpretation assumes Aristotle had a modern understanding of the concept of the physical. Instead, they argue that Aristotle, who required an essentially living body as a prerequisite, found it impossible for a substance without life to have a physical state. Some even argue that Aristotle had no understanding of the process of physiological change necessary to realize a mental state.⁹

When considering these different arguments about Aristotle’s understanding of the continuity of material and physical states in *De anima* and the association with hylomorphism, it is important to consider ‘innate *pneuma*’, a key substance involved in physiological processes. Is it true that Aristotle, as past researchers suggest, understood life activities through ‘innate *pneuma*’ without any consideration of physiological processes?

One clue lies in Aristotle’s *pneuma* theory, as reconstructed from his biological writings. Using these writings, his ideological conceptualization of ‘innate *pneuma*’ becomes much clearer. However, few scholars have yet considered this question through the lens of Aristotle’s *Corpus Hippocraticum*, an important writing on the topic.¹⁰ This paper intends to rectify that gap, by clarifying the relationship between embryology in the *Corpus Hippocraticum* and Aristotle’s *De generatione*

animalium and examining how Aristotle accepted and criticized contemporary medical understandings of *pneuma*.

2. *Pneuma* vs. *Aether* in *De generatione animalium*

Before examining Aristotle’s medical viewpoint, we must first consider his view of *pneuma* in *De generatione animalium*. Most of the discussion of *pneuma* appears in Volume 2 in connection with the nature of sperm (II [2]), the aporia of the functional transfer of the soul (II [3]), and the development and differentiation of the foetus (II [4ff.]). *Pneuma* plays a particularly important role in the second of these discussions. Aristotle believes that the sperm and menstrual blood, respectively, are the formal (primary) cause and material cause, and that *pneuma* acts as the intermediary between the two.

Aristotle writes that the sperm makes menstrual blood move ‘by the same movement as itself is moved’ (737a21ff.), meaning that the substance of menstrual blood is formed in the movement from the possible to the actual. In explaining the abilities of the soul within the context of functional transmission, Aristotle describes *pneuma* as analogous to *aether* (the upper fiery-air):

Now so far as we can see, the faculty (δύναμις) of Soul of every kind has to do with some physical substance which is different from the so-called ‘elements’ (στοιχείον) and more divine than they are In all cases the semen contains within itself that which causes it to be fertile (γόνιμα)—what is known as ‘hot substance’ (θερμόν), which is not fire nor any similar substance, but the *pneuma* which is enclosed within the semen or foam-like stuff, and the natural substance which is in the *pneuma*; and this substance is analogous to the element which belongs to the stars. (*De generatione animalium*, Book II, Peck 1949, p. 171, II 736b30-737a)

This passage was often used as a source for vitalist understandings of life in philosophy and medicine until the 18th century, and its meaning has been much debated over time. Although

later vitalists' characterization of *pneuma* as supernatural spiritus is far from Aristotle's original conception, it is not unusual, even today, to interpret *pneuma* as a special substance analogous to *aether*.¹¹

Solmsen is one of the scholars who use this understanding of *pneuma*. He claims the analogy is meant to explain the transmission of the soul and interprets the description of sperm in this passage (II [3]) as a 'new discovery' that abandons the premises of Aristotle's previous theories.¹² In other words, Solmsen believes that Aristotle is moving beyond his description of 'sperm as a nutritional surplus' (περίττωμα), coming to believe that sperm must contain all possible functions of the soul. For Solmsen, the sperm provides heat, which acts as a medium for the nutritional soul, and *pneuma* serves as a medium for the sensory soul; heat alone cannot explain transfer from spirit to matter.

Similarly, Peck emphasizes the analogy of *pneuma* as *aether*, broadly interpreting *pneuma* as the primary cause.¹³ According to Peck, both actions move matter, but 'they do not suffer qualitative changes themselves'. *Aether* itself is stationary, but moves the outermost celestial sphere of the sky, thereby conveying its movement to the inner celestial spheres and celestial bodies. Likewise, in reproduction, *pneuma* is a mediator between the nonmaterial initiator (soul) of movement and material objects. Nussbaum, meanwhile, is critical of the idea, saying that *pneuma*'s operation on the four elements (fire, air, water, earth) is obscured by using such analogical language.¹⁴

All of these interpretations emphasize the analogous relationship between *pneuma* and *aether*. All, therefore, contain arguments that are incompatible with Aristotle's discussion of specific physiological function and contradict his notion that the work of the soul is basically nutrition intake. Criticizing this point, Balme et al. assert that the analogy should be understood in accordance with Aristotle's discussion of 'heat' (θερμὸν) and in relation to other writings.¹⁵ They believe that *aether* is analogous, not to *pneuma*, but rather to the 'life heat' that is a part of *physis*. Aristotle believed that this life fever is a 'divine thing' that differs from fire, one of the four elements that is eventually extinguished (cf. *De philosophia*). This heat is indispensable for

maintaining the physical body (cf. *De longitudine et brevitae vitae*, 466b16ff.; *De jusventute et senectute/De vita et morte*, 470a19ff.; *De respiratione*, 479a29ff.). Unlike fire, life heat is not extinguished but gradually changes nutrients into various homogeneous units through special logos, a continual process that preserves the persistence of animal and plant bodies. It is thus a natural process; Aristotle believed that the digestion of nutrients is due to the heat held in the centre of the body (cf. *De partibus animalium*, 650aff.), and its source, the heart, is the first organ to form within a foetus (cf. *De generatione animalium*, 740a17f., 742b36ff.). Therefore, Aristotle thought that life-power derived from heat in the heart.

If *pneuma* is understood in this way as 'heat', then one cannot interpret the analogy of *pneuma* as *aether* separately from the earlier notion of 'sperm as a surplus of nutrition'. Sperm, Aristotle believes, is a surplus that corresponds to the 'ultimate' (τὸ ἔσχατον) of nutrition (725a12), and we can regard the interaction between 'innate *pneuma*' contained therein and heat as demonstrated in Volume I. For nutrition to be the final product, it must be formulated through the stomach, liver, and spleen before reaching the heart (*De partibus animalium*, 670a19ff.), where the 'innate *pneuma*' is generated as 'steam,' (πνευμάτωσις) and the heart's heat transforms nutrients into blood (*De respiratione*, 480a16). Therefore, the *pneuma* is not limited to the functional transfer of the soul, as Solmsen describes, but already plays a material role in physiological processes prior to being generated as a surplus. Moreover, other descriptions throughout Aristotle's biological writings, together with *De generatione animalium*, show the true essence of *pneuma* as both heat and physical activity at the level of 'substance'. This heat can be contrasted with the divine heat described in the previous quotation.

3. 'Innate Pneuma' as a Critique of the Medical Pneuma Theory

3.1 Pneuma in the Knidian Medical Corpus

The next question to answer is that of the relationship between Aristotle's theory of *pneuma* and pre-Aristotelian medical understandings of *pneuma*. Multiple scholars have pointed out that

Aristotle's idea of 'innate *pneuma*' is directly influenced by Sicilian medical philosophers such as Empedocles, Philition, and Diocles.¹⁶

There can be no doubt that Aristotle, who references multiple previous theories, discusses the *pneuma* of embryology.¹⁷ However, when considering the consistency of Aristotle's embryology with the idea of *pneuma* in other understandings of reproduction, it is critical to note the connections between the works of the *Corpus Hippocraticum* (*De genitura*, *De natura pueri*, *De morbis* IV)¹⁸, considered to be written by the Knidian school, and *De generatione animalium*.¹⁹ Given these connections, while it is possible Aristotle's theory of *pneuma* derives from fragmentary references to Sicilian medicine, it is more fitting to assume that *De generatione animalium* was inspired by the medical corpus of the Knidian school and its systematic theoretical construction of embryological processes. Therefore, the following sections examine the similarities between *pneuma* in both Aristotle's and the Knidian school's medical corpus. Specifically, I focus my analysis on Volumes I and II (4ff.) of *De generatione animalium* and the discussions of 1) 'sperm as nutrient surplus' and 2) 'specialized functions of foetal *pneuma*'. By doing so, I hope to clarify the essential and unique characteristics of Aristotle's theory of 'innate *pneuma*'.

3.2 'Sperm as Nutrient Surplus'

In Volume I of the *De generatione animalium*, Aristotle criticizes 'the melting theory of sperm' (724b35ff.), referring to 'fusion' (σύντηγμα) separated by unnatural means from the substances responsible for growth (724b27f.). Aristotle also criticizes the pangenesis theory, or the idea that 'sperm comes out from the whole body' (724b35f.), a view found in the *Corpus Hippocraticum* and held by Empedocles and Democritus, along with many of Aristotle's predecessors.²⁰ Some scholars, meanwhile, attribute the melting theory to Empedocles and his followers; however, there is not enough evidence to support this view.²¹

All in all, while Aristotle criticizes much of the Knidian medical corpus, which developed both the pangenesis theory and the melting theory,²² he accepts certain aspects of their sperm theory. For example, within the

Knidian school, sperm is the most powerful of the naturally occurring internal body fluids—the others being 'blood, bile, water, mucus' (αἷμα, χολή, ὕδωρ, φλέγμα)—and is produced when separated (ἀποκρίνω) from these other fluids (c.1, c. 3: VII 470, 2-3; 474, 5-8L [citation indicates page number and line number of Litre version]). Bodily fluid melts (διαχέω) due to the heat generated during intercourse, and through the movement a foamy substance is produced (ἀφρῆει): sperm (470, 9-10L). Sperm is carried along passageways located throughout the entire body (470, 13-4L) by heat before being 'separated from the whole body' (ἀποκρίνεσθαι ἀπὸ παντὸς τοῦ σώματος) (474, 5L) and discharged. As in this Knidian understanding of sperm, Aristotle describes in *De generatione animalium* how the nature of sperm is to endure vigorous motion and bubbling, due to heat that forms sperm as a final product.

Regarding the passing on of genetic traits and the determination of both sexes, there are few theoretical differences between *De generatione animalium* and *De genitura*.²³ *De genitura* states that a child's resemblance to one parent is determined by which parent has quantitatively more sperm (c.6ff.). Likewise, *De generatione animalium* attributes the passing on of traits to the mixing of male and female reproductive fluids. Thus, *De genitura* and *De generatione animalium* have more in common when it comes to their explanations of sperm's physiological effects than they do with Empedocles' embryology.

3.3 'Specialized Functions of Foetal *Pneuma*'

As described below, the Knidian medical theory of differentiation of foetus serves as the basis for both the pangenesis theory and the melting theory. In particular, the term *pneuma* is characteristically used in *De natura pueri* (c.12, c.17) to explain the origins of foetal breathing. However, it is also used to describe 'differentiation'; the constituents of sperm, coming from all parts of both parents, are 'carried to a unique place' (496, 20L). This is nearly indistinguishable from the 'from the whole body' theory in *De genitura* (c.1-8). This substance differentiates between the mother's *pneuma* and the foetus' own *pneuma*. In other words,

‘sperm and flesh are differentiated (διορθροῦται), whereupon similar things come to resemble one another’ (τὸ ὅμοιον ὡς ὅμοιον) (498, 24 f.L).

Although Aristotle criticizes both the pangenesis and melting theories, these ideas are interlocked with his idea of ‘the differentiation function of foetal *pneuma*’, and all develop together within his medical corpus. Aristotle believes that ‘sperm as a nutritional surplus’ gives sperm the *dynamis* to send it ‘to the whole body’, which leads to the conclusion that there is some ‘differentiation function of foetal *pneuma*’ intrinsic to sperm. That is, the foetus takes in nutrients not due to its mother’s *pneuma* or its own intake of anything from the outside, but via its own sperms’ *dynamis* (741b37f.). Aristotle clearly shows that there is no need to assume that sperm will melt from the ‘whole body’, nor that ‘similar things are conveyed to what is similar’ (φέρεσθαι τὸ ὅμοιον πρὸς τὸ ὅμοιον) (740b15, cf. 741b10).

Similar terminology shows that these assertions of Aristotle’s are intended to criticize the Knidian medical corpus. However, he is not criticizing the function of *pneuma* itself; although Aristotle is skeptical of Knidian medical beliefs, it is clear that at the foundation of his embryology lies ‘differentiation (διορίζεται/διορθροῦται)’ (741b37, 742a7) of the *pneuma* via the physiological processes.

4. The Relationships between *Pneuma* and Heat

As briefly discussed above, Aristotle’s criticism and acceptance of the medical corpus’ *pneuma* theory allows us to understand his own ‘innate *pneuma*’ idea as a process of physical change. The medical corpus includes the idea of a physiological mechanism by which body fluids and fever work together to form *pneuma* theory. In the Knidian medical corpus, the melting of body fluids results from ‘suction’ (ἔλκειν) produced by the interaction of humidity and heat; the importance of this suction is pointedly emphasized and results in a consistent physiological mechanism.²⁴ The Knidian medical corpus understands there to be four bodily reservoirs (πηγή)—‘heart, head, spleen, liver’; these cavities cause suction that draws liquid (blood, mucus, water, or bile) from the belly

(c.33ff.). The document repeatedly explains that the structure capable of using suction on substances exists to fill these bodily cavities (c.2, 9, 19, 21, 22, 25, 50-53). More precisely, suction is caused by the power of the *pneuma*, the heat nutrient in reserve (cf. c.12, c.17). Therefore, ‘by heat and the power of *pneuma*’ is understood as the first principle that explains physiological change in Knidian medical theory.

In contrast, Aristotle explicitly denies ‘by *pneuma*.’ The Knidian medical corpus describes the mechanism of the cavities as ‘like a cupping glass’ (ὡσπερ σικύη) (c.35: VII 548, 18L),²⁵ but Aristotle claims that sperm’s movement is not due to *pneuma*, but that it is sent naturally to the reproductive organs:

Each of the residues is carried to its proper place without the exertion of any force from the *pneuma* and without compulsion by any other cause of that sort, although some people assert this, alleging that the sexual parts draw the residue like cupping-glasses and that we exert force by means of the *pneuma*, as though it were possible for the seminal residue or for the residue of the liquid or of the solid nourishment to take any other course unless such force were exerted. The reason given for this view is that our discharge of these residues is accompanied by the collecting of the *pneuma*. (*De generatione animalium*, II 737b28ff., Peck 1949: 179)

It is certainly the case that there are no differences between the Knidian medical corpus and *De generatione animalium* when it comes to the phenomenon of sperm being drawn and discharged by heat. As Coles points out, as long as there is no distinction made with regard to the ‘time and place’ of sperm production, there is no fundamental difference between the theories.²⁶ However, as described earlier, the Knidian school understands the cause of ‘suction power’ as the structure of the body. In contrast, by making sperm a ‘surplus’ of nutrition and suggesting that the heart is the first organ to form in a foetus, Aristotle clarifies that the drive to circulate and discharge sperm comes from the heart’s heat. This way of thinking is based on the notion that *pneuma*, generated by the heat of the heart, has

the power to go ‘to the whole body’. In this way, the specific mechanism of heat that resides in the central part of the body clearly differentiates *De generatione animalium* from the Knidian medical corpus.

Attempting to differentiate the work of ‘innate *pneuma*’ from the four elements is likely to disrupt the attempt to capture the true image of ‘innate *pneuma*’. In one sense, *pneuma* is a tool that cannot be reduced to an action of one of the four elements (*De generatione animalium*, V 789b8f.): it accompanies the life heat intrinsically related to life itself. However, it never works apart from qualitative change or without the four elements’ actions. ‘Innate *pneuma*’ is different from air because heat exists in the centre of the body, guaranteeing organic unity of life. ‘Innate *pneuma*’ inflates and shrinks at the heart, ‘causing movement without qualitative change’ (*De motu animalium*, 703a24-5) not because physical change cannot be seen, but instead because it is located in the heat in the centre of the body, continually renewed as the same thing, thus acquiring stability and homeostasis.

Conclusion

As described in this paper, Aristotle’s theory of *pneuma* is not simply a denial of the Knidian idea of the substance-like action of *pneuma* as air. Instead, Aristotle’s emphasis on the mechanical structure of *pneuma* and heat and the functional transmission of the soul in *De generatione animalium* can be understood as inherited from the Knidian medical corpus’ focus on physical change.

Understood in this way, it becomes clear that Aristotle developed ‘innate *pneuma*’ to solve problems in his own medical ideas, and therefore the concept has implications for explaining the physiological mechanism of the organic body. The differences in format and methodology between the discussions in *De anima* and other various biological writings remain as further problems for consideration. However, this paper contradicts previous standard interpretations of Aristotle’s theory of *pneuma* as a new concept introduced to defend hylomorphic and perceptual theories and simultaneously forms a firm grounding for an interpretation of *pneuma* on the level of sense perception and thought, based

on nutrient intake with accompanying material changes.²⁷

Endnotes

- 1 A major portion of this paper was previously published as “Vital heat, *pneuma*, and *aether*” by Shino Kihara in *The Logos of the Flux—Heraclitus and Ancient Greek Medicine*, pp. 157-171, 2010 (in Japanese).
- 2 Solmsen and Preus typify this interpretation (Solmsen, F., “The Vital Heat, the Inborn *Pneuma*, and the *Aether*,” *Journal of Hellenic Studies*, 77, 1957; Preus A., *Science and Philosophy in Aristotle’s Biological Works*, Olms, 1975).
- 3 Among the recent interpretations are attempts to reconstruct material changes from fragmentary references to the concept of *pneuma* in Aristotle’s biological works (cf. Freudenthal, G., *Aristotle’s Theory of Material Substance: Heat and Pneuma, Form and Soul*, Oxford, 1995; Bos, A., “Pneuma as Quintessence of Aristotle’s Philosophy,” *Hermes*, 141, 2013). In this article, by clarifying these physiological changes as well as reconsidering Aristotle’s intention in introducing ‘innate *pneuma*’ into physiology, I aim to emphasize the uniqueness of Aristotle’s concept of *pneuma* by way of contrasting his ideas with contemporary medical understandings of the topic.
- 4 For quotations of fragments from pre-Socratic philosophers, I follow Diels, H. u. Kranz, W., *Die Fragmente der Vorsokratiker*, 6th ed., Berlin, 1951-2 [=DK].
- 5 See Homer, and others such as Pherecydes (DK7A5), Xenophanes (DK21A1), Epicharmus (DK23B22, B49), Empedocles (DK31B136), Anaxagoras (DK59A93), Democritus (DK68A103, B18). Both ‘wind’ and ‘breath’ bear a relationship to the origin of the word ψυχή.
- 6 In both Aristotle and the *Corpus Hippocraticum*, the meanings of σπέρμα and γονή are used without any basic differentiation between them. In this paper, I unify their translations as ‘sperm’, a biological term that encompasses the meanings of ‘seed’ and ‘semen’.
- 7 Nussbaum’s interpretation emphasizes this point (Nussbaum, M.C., *Aristotle’s De motu animalium*, Princeton, 1978).
- 8 Nussbaum, M.C. & Putnam, H., ‘Changing Aristotle’s Mind’, in *Essays on Aristotle’s De Anima*, ed. Nussbaum & Rorty, Oxford, 1992.
- 9 Interpretation by Burnyeat and Johansen (Burnyeat, M.F., ‘Is An Aristotelian Philosophy of Mind still Credible?’ In *Essays on Aristotle’s De Anima*, ed. Nussbaum & Rorty, Oxford, 1992; Johansen, T.K., *Aristotle on the Sense-Organs*, Cambridge, 1998). These can be contrasted with Sorabji’s interpretation, which acknowledges physiological changes (Sorabji, R. ‘Intentionality and Physiological Processes: Aristotle’s Theory of Sense-Perception’, in *Essays on Aristotle’s De*

- Anima*, ed. Nussbaum & Rorty, Oxford, 1992).
- 10 As to the relationship between the *Corpus Hippocraticum* and the work of Aristotle, as is already demonstrated in several comparative studies, despite the paucity of the sources available, there is no doubt that Aristotle relies on established medical tradition (cf. Tracy, T.J., *Physiological Theory and the Doctrine of the Mean in Plato and Aristotle*, The Hague - Paris, 1969; Van der Eijk, P.J., 'Aristotle on "distinguished" physicians and on the medical significance of dreams', *Ancient Medicine in its Socio-Cultural Context*. 13-15 April 1992, Amsterdam, 1995, etc.). However, there are only a few studies that discuss the medical ideological background of 'innate *pneuma*', and in most cases there is no reference to the relationship between Aristotle's *pneuma* and that of the *Corpus Hippocraticum*.
 - 11 Compared to the interpreters mentioned below in the main text, Preus in particular (*op. cit.*, p. 90) has a strong tendency to interpret *pneuma* as a transcendental substance. According to him, Aristotle places emphasis on *pneuma* being a special material different from what can be found empirically. Furthermore, Preus sees Aristotle as a mythmaker and points out that in explanations of origins, consistent interpretation of hylomorphism of the soul is difficult.
 - 12 Solmsen, *op. cit.*, p. 121f.
 - 13 Peck, A. L., 'The Connate *Pneuma*', in *Science, Medicine and History*, ed. E. Ashworth Underwood, Oxford, 1953, p. 118 (cf. Peck, A.L., *Aristotle, Generation of Animals*, Cambridge, Loeb Classical Library, 1942.)
 - 14 Nussbaum, *op. cit.*, p. 161.
 - 15 Balme, D.M., *Aristotle's De Partibus Animalium I and De Generatione Animalium I*, Oxford, 1972, 1992, p. 163. However, because it does not distinguish 'life heat' from the heat of a fire, Balme's interpretation is insufficient. (cf. Freudenthal, *op. cit.*, p. 116ff.). In Aristotle's biology and soul theory, 'life heat' is related to nutritive and intelligence activities by constantly interacting with cold or other elements. For example, in a nutritive soul, a living body digests taken foods using its own 'vital heat' and maintains own existence. Furthermore, in a perceptual soul, 'vital heat' surrounding the heart is connected with the mechanism of the five senses.
 - 16 Jaeger W., *Diokles von Karystos*, 1963, p. 216; Solmsen, *op. cit.*, p. 120/1; Longrigg, J., *Greek Rational Medicine*, London & New York, 1993, pp. 173ff. According to Empedocles, 'The fetus is not an animal; it has no breath (ἄπνοον) in the uterus' (Aetius, V 15, 3; cf. DK31A74 (Aetius IV 22, 1)). He also speaks of foetal nutrients as 'breathing material (πνευματική)' (DK31A79). The influence of Diocles (Fr.172) is positively asserted by the early Jaeger (Jaeger, W., 'Das Pneuma im Lykeion', *Hermes* 48, 1913, pp. 51-57), but later, Jaeger revises his own assertion, acknowledging that the assumption on the influence is somewhat problematic.
 - 17 Besides Empedocles, according to Diogenes, 'sperm is an air-flowing thing (πνευματῶδες)' (DK64B6). According to Democritus' description, '(Sperm)'s ability (δύναμις) is also an object. This is because it has the character of *pneuma* (πνευματική)' (DK68A140).
 - 18 For the text of the *Corpus Hippocraticum*, I use Littré (Littré, E., *Œuvres complètes d'Hippocrate, Traduction nouvelle avec le texte grec en regard*, Tome VII, Paris, 1851 / Hakkert, A. M., Amsterdam, 1962) (cf. Joly, R., *Hippocrate Tome XI: de la generation / de la nature de l'enfant / des maladies IV / du foetus de huit mois*, Les Belles Lettres, 1970). Since Littré, it has been a commonly accepted view that the *Corpus Hippocraticum* comes from the same authors. A detailed examination comes from Lonie (Lonie, I.M., *The Hippocratic Treatises 'On Generation', 'On the Nature of the Child', 'Diseases IV', Ars Medica II. Abteilung, Band 7*, New York, 1981, pp. 43-51).
 - 19 Judging from the influence of Democritus, the usage of scientific vocabulary, the contents of the discussion, and so on, it is estimated that the time of writing of this Knidian document is around 420-400 BCE (Lonie, *op. cit.*, pp. 71ff.). Also, it is pointed out through vocabulary research that the embryology of Hippocrates cannot have come after Aristotle (Dean-Jones, L., *Women's Bodies in Classical Greek Science*, Oxford, 1994, pp. 19f.). Therefore, in the documents of the Knidian School and in *De generatione animalium*, the thought of Empedocles, Diogenes, and in particular the embryology of Democritus, act as common antecedents. Although there is room for discussion about the influence of Plato's theory of *pneuma* as articulated in the *Timaeus*, we must discuss it on another occasion, since it is outside the scope of this paper. Focusing on an altogether different meaning, below I examine the inheritance of the discussion of the workings of mechanical *pneuma*.
 - 20 The first volume distinguishes between the complete pangensis theory and Empedocles' semi-pangensis theory (764b10ff.). The name of Democritus is listed under this theory.
 - 21 Based on DK31B68, Longrigg (Longrigg, J.L., 'A Seminal "Debate" in the Fifth Century BC?', In *Aristotle on Nature and Living Things*, ed. Gotthelf, A., Bristol, 1985) claims Empedocles is the first to connect sperm with blood. In particular, Longrigg sees that Aristotle believes sperm to be transformed blood, thus emphasizing the existence of Empedocles and Diogenes' theory of sperm as a background. But Coles (Coles, A., 'Biological Model of Reproduction in the Fifth Century BC and Aristotle's Generation of Animals', *Phronesis* 40, 1995, pp. 54-57) suggests that Empedocles' fragments do not provide such evidence and criticizes Longrigg for the following reasons: (1) sperm is generated through heat, (2) association of sperm and pangensis theory, and (3) a connection between blood and growth promoting substances. In addition, Coles points out that, in Diogenes,

it was unclear whether blood was regarded as a nutrient.

- 22 Peck (1942, *op. cit.*, p. 78) argues that it is inappropriate to apply the melting theory to *De genitura*, and Balme (*op. cit.*, p. 146) points out that there is no vocabulary (σύντηγμα) equivalent to ‘melting substance’ used in this document. However, given the frequent use of the term διαχέω to explain melting, the melting theory that Aristotle had in mind would have been associated with this medical document.
- 23 Dean-Johnes, *op. cit.*, pp. 225ff., Coles, *op. cit.*, pp. 71ff.
- 24 Cf. Lonie, *op. cit.*, pp. 266ff.
- 25 Cf. *Timaeus* 79e10, *De vetere medicina* c.22, *De ossium natura* c.15.
- 26 Coles, *op. cit.* p.62. The explanation of the mechanism of suction by heat cannot be said to have been rejected by Aristotle. For example, *Meteorologica* 379a23ff., 380b22; *De partibus animalium* 672b29, 673b7; *De generatione animalium* 739bff.; especially the relationship with intrinsic heat in *Meteorologica* 355b10.
- 27 The controversy of vitalism versus mechanism since the 16th century comes from Aristotle’s theory of *pneuma*. But as we saw in this paper, Aristotle’s own argument is not valid either. For this point, please refer to Shino Kihara, *op. cit.*, p. 172 (in Japanese).