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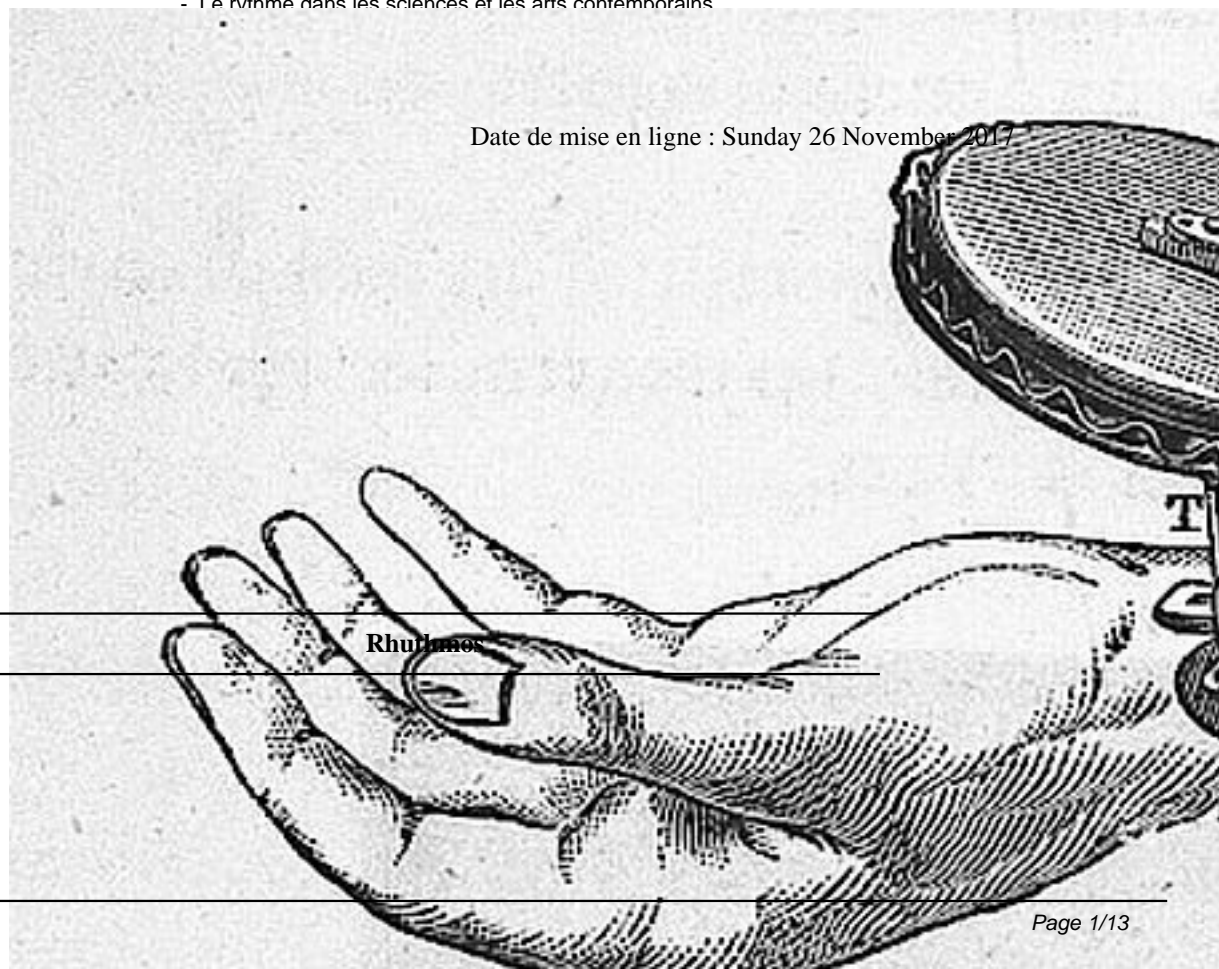
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# The Spread of Rhythm in Life Science and Medicine (4th - 3rd century BC) - Part 1

- Recherches

- Le rythme dans les sciences et les arts contemporains

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In this chapter, I would like to present the main channels of the spreading of rhythm under its Platonic guise in life science and medicine during the end of the 4th and the 3rd centuries. I will naturally use the expression "life science" as a handy way to denote studies that were not considered yet as constituting a unified domain. To avoid any misunderstanding, I would like to emphasize also that I won't discuss the various doctrines of ancient philosophers and physicians for their own sake, nor the complex web of influences that can be traced in each one of them. My only interest is to assess how the term *rhuthmys* was used in these new domains of knowledge and what novel features could have resulted from these new usages. Before addressing the works of some of the greatest 3rd century physicians, it is yet necessary for the sake of clarity to recall, at least briefly, a few contributions made during the two previous centuries.

## Respiration and Pulse without Rhythm - Hippocratic School (5th cent. - 4th cent. BC)

There is no extant evidence that the term *rhuthmys* was already used by the Greek physicians of the 5th century to refer to the respiration (ἄναπνοη - *anapnoê*) or to the pulse (σφύγμη - *sphugmys*). In Hippocrates (ca. 460-ca. 370 BC) the latter term did not denote a natural and regular physiological motion in the body but unnatural motions caused by disease or extreme emotion e.g. in *Prognostics* (second half of the 5th century) and *Epidemics* (ca. 410 BC). The pulse was not clearly constituted as a medical or scientific object.

The Liddell-Scott-Jones dictionary mentions one occurrence of *rhuthmys* in the Hippocratic writings but it clearly has the pre-Platonic meaning of "shape."

And a small shoe made of lead is to be bound on externally to the bandaging, having the same shape as the Chian [from Chios] slippers had [ἡμοίωτον ἢ τῶν χιανῶν ἰσθμῶν, ἡμοίωτον ἢ τῶν χιανῶν ἰσθμῶν - *hoïon ai khiai krêpîdes Rhuthmôn eîkhon*]. (Hippocrates, *On the Articulations*, trans. Charles Darwin Adams)

The same seems to be the case with most Hippocratic physicians in the 4th and the 3rd centuries. Diocles of Carystus (ca. 375 BC - ca. 295 BC) lived and worked in Athens, where he wrote what may be the first medical treatise in Attic, not in Ionic as was customary in Greek medical writings [1]. His most important work was in practical medicine, especially diet and nutrition, but he also wrote the first systematic textbook on animal anatomy. The remaining fragments of his works have been recently collected and translated into English by Philip van der Eijk, with a commentary in a separate volume. Apparently, they show nothing specific on pulse nor any use of the term

*rhuthmys* to denote the pulse (see Index in Philip van der Eijk, 2000).

Praxagoras (ca. 340 BC - ?) was another emblematic figure of the Hippocratic school [2]. Very little is known about his life, except that he was born on the island of Kos in a family of physicians. His grandfather had been one of Hippocrates' students. None of his writings has survived. Most remaining fragments we owe to Galen, Rufus, Athenaios, Pliny, and a few others sources.

Praxagoras studied Aristotle's anatomy. He opposed the view that arteries carried only liquids. Instead, he saw them as tubes, similar to the trachea and bronchi, which carried *pneuma*, the mystic force of life. Arteries took the breath of life from the lungs to the left side of the heart and through the aorta to the arteries of the body. The veins came from the liver and carried blood, which was created by digested food, to the rest of the body. The combination of blood and *pneuma* generated heat.

Despite these errors, Praxagoras was apparently the first to direct attention to the importance of arterial pulse in diagnosis. He discovered that pulsation only occurs in the arteries, not in the veins. But, at the same time, he insisted that arteries pulsed by themselves and were independent of the heart (Galen, *De pulsuum differentiis*, 4.2, 8.702-3). Moreover, according to him, the pulse (ἄρρυθμῶς - *sphugmys*) did not differ essentially but only in magnitude from palpitation (ἄρρυθμῶς - *palmys*), spasm (ἄρρυθμῶς - *spasmys*) and tremor (ἄρρυθμῶς - *trymos*). All four motions were forms of ἄρρυθμῶς - *pathê* or involuntary movements of the arteries (Galen, *De puls. diff.*, 4.2, 8.716, see also 4.3, 8.723, and Pseudo-Rufus, *Synopsis de pulsibus*, 2, ed. Daremberg & Ruelle, 1879, p. 220).

Nothing extant from the Hippocratic writings seems to show any use of the term *rhuthmys* to characterize the respiration which is called *anapnoê* nor the pulse which is always referred to as *sphugmys*.

## Respiration and Pulse without Rhythm - Plato, Aristotle (4th cent. BC)

When Plato (428/427-348/347 BC) in the *Timaeus* (361-347 BC) describes the respiration, which, he believes, is related to the heart beat and digestion, he never uses the term *rhuthmys* either to designate its alternating movement (33c, 78e, 79e). He only refers to the pair of words  $\mu\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$  - *eispnoê* - inspiration and its opposite  $\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$  - *ekpnoê* - expiration. The pulse is only vaguely alluded to through "the inward fire attached thereto" that is  $\delta\iota\alpha\iota\omicron\rho\acute{\upsilon}\mu\epsilon\nu\omicron\nu$  - *diaiôroumenon* - moving to and fro. This fire, which maintains life, dissolves the meats and drinks, divides them into particles and forces them into the veins, "as through pipes," where they are transported to all parts of the body.

And to this kind of process the Giver of Titles gave, as we say, the names of "inspiration" and "expiration" [ $\mu\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$   $\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$  - *anapnoên kai ekpnoên*]. And the whole of this mechanism and its effects have been created in order to secure nourishment and life for our body, by means of moistening and cooling. For as the respiration [ $\mu\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$   $\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$  - *anapnoês*] goes in and out [ $\mu\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$   $\omicron\acute{\alpha}\nu\eta\sigma\iota\varsigma$  - *eisô kai êxô*] the inward fire attached thereto follows it; and whenever in its constant oscillations [ $\delta\iota\alpha\iota\omicron\rho\acute{\upsilon}\mu\epsilon\nu\omicron\nu$  - *diaiôroumenon* - moving to and fro] this fire enters in through the belly and lays hold on the meats and drinks, it dissolves them, and dividing them into small particles it disperses them through the outlets by which it passes and draws them off to the veins, like water drawn into channels from a spring; and thus it causes the streams of the veins to flow [ $\tau\omicron\nu$   $\phi\lambda\epsilon\beta\omicron\nu$   $\rho\eta\upsilon\mu\alpha\tau\alpha$  - *tôn phlebôn poieî rheûmata*] through the body as through a pipe. (Plato, *Timaeus*, 78e-79a, trans. W.R.M. Lamb)

The heat, which resides inside the body as the living principle, "flows" as an internal "fire font." The respiration, whether by the lungs or the skin, functions as a cooling system that alternatively brings into the body fresh air and expels the heat in excess out of it. The alternation of inspiration and expiration is like "a wheel that oscillates backwards and forwards [*saleuymenon* means *causing to rock, making to oscillate*; *apeirgasménon* means *to finish off, to complete*]."

The originating cause of these processes we must assume to be this. Every living creature has its inward parts round the blood and the veins extremely hot, as it were a fount of fire residing within it [...] Now we must agree that heat, by Nature's law, goes out into its own region to its kindred substance; and inasmuch as there are two outlets, the one out by way of the body, the other by way of the mouth and the nose, whenever the fire rushes in one direction it propels the air round to the other, and the air which is thus propelled round becomes heated by streaming into the fire, whereas the air which passes out becomes cooled. And as the heat changes its situation and the particles about the other outlet become hotter, the hotter body in its turn tends in that direction, and moving towards its own substance propels round the air which is at the former outlet; and thus the air, by continually undergoing and transmitting the same affections, causes inspiration and expiration [*½±Ä½¿t½ °±v °Ä½¿t½ - anapnoên kai ekpnoên*] to come about as a result of this double process, as it were a wheel that oscillates backwards and forwards [*ºº»¿½ ¿UÄÉ Ä±»µÄ¼µ½¿½ ½± °±v ½± Äµ¹Ä³±Ä¼-½¿½ - kúklon houtô saleuymenon énthā kai énthā apeirgasménon*]. (Plato, *Timaeus*, 79c-79e, trans. W.R.M. Lamb)

In the *Phaedrus* (251d) an anguished soul, separated from a youth's beauty, throbs like a pulse in fever. But this use of pulse (*ÄÆÄ¾Ä - sphugmys*) is still consistent with the older meaning referring primarily to violent motions and pathological symptoms associated with fear or fever (van Staden, 1989, p. 268).

Aristotle (384-322 BC), who seems more familiar than Plato with the Hippocratic Corpus, explicitly rejects Plato's theory of respiration but only on the ground that inspiration, according to him, is not second to expiration but comes first. For the rest, he replicates the view of the heat as living principle and of the respiration as cooling system. In this context, he never uses the term *rhuthmys* either.

In *µÁv ½µlÄ·Ä¿Ä °±v ³ÄÉÄ, °±v ¶ÉÆÄ °±v ½±½-Ä¿Ä, °±v ½±Ä½¿ÆÄ - Peri neótêtos kai gênôs, kai zôês kai thanátou, kai anapnoês - On Youth, Old Age, Life and Death, and Respiration*, written around 350 BC, he claims that inspiration and expiration "go on in alternation" or "one after the other" in that order.

Further, the method of explaining [the respiration] involves a fiction. It is said [by Timaeus] that when the hot air issues from the mouth it pushes the surrounding air, which being carried on enters the very place whence the internal warmth issued, through the interstices of the porous flesh; and this reciprocal replacement is due to the fact that a vacuum cannot exist. But when it has become hot the air passes out again by the same route, and pushes back inwards through the mouth the air that had been discharged in a warm condition. It is said that it is this action which goes on continuously when the breath is taken in and let out expire [*½±Ä½¿½ÄqÄ Äµ °±v °Ä½¿½Ä±Ä - anapnéontas te kai ekpnéontas*]. But according to this way of thinking it will follow that we breathe out before we breathe in. But the opposite is the case, as evidence shows, for though these two functions go on in alternation [*³w½µÄ±¹ ¼r½ ³pÄ »»u»¿¹Ä Ä±æÄ± Ä±Ä' »»»± - gínetai mèn gàr allêlois taúta par' állêla - lit. occurs indeed one after the other*], yet the last act when life comes to a close is the letting out of the breath, and hence its admission must have been the beginning of the process. (Aristotle, *On Respiration*, part 11, trans. G. R. T. Ross)

## The Spread of Rhythm in Life Science and Medicine (4th - 3rd century BC) - Part 1

Aristotle, borrowing from the earlier Hippocratic treatise *On Regimen* (5th century), compares many times the lungs to double bellows, but their alternation is never qualified as rhythm or rhythmic. The influence of heat forces the lungs to expand, causing inhalation, and this introduction of cold air from outside causes in turn contraction and exhalation.

For when the breath is not let out and the heat accumulates too much then we need to respire, and to respire we must draw in the breath. When hot, people breathe rapidly [ $\rho\alpha\lambda\lambda\acute{\alpha}\kappa\iota\varsigma$  - *dè pollákis anapnéousin* - lit. breathe many times or often], because they must do so in order to cool themselves. (Aristotle, *On Respiration*, part 10, trans. G. R. T. Ross)

The chest is raised in the manner of a forge-bellows when the breath is drawn in. It is quite reasonable that it should be heat which raises up and that the blood should occupy the hot region. But it collapses and sinks down, like the bellows once more, when the breath is let out. The difference is that in a bellows it is not by the same channel that the air is taken in and let out [ $\kappa\alpha\tau\grave{\alpha}\tau\alpha\upsilon\tau\acute{\omicron}\nu\epsilon\iota\sigma\delta\acute{\epsilon}\kappa\eta\omicron\nu\tau\acute{\alpha}\iota\tau\epsilon\tau\acute{\omicron}\nu\alpha\acute{\epsilon}\rho\alpha\kappa\alpha\iota\pi\acute{\alpha}\lambda\iota\nu\epsilon\chi\iota\acute{\alpha}\sigma\iota\nu$ ], but in breathing it is. (Aristotle, *On Respiration*, part 13, trans. G. R. T. Ross)

In similar fashion as the fish move their gills, respiring animals with rapid action [ $\rho\alpha\lambda\lambda\acute{\alpha}\kappa\iota\varsigma$  - lit. often, many times] raise and let fall [ $\acute{\alpha}\nu\omicron\kappa\alpha\iota\kappa\acute{\alpha}\tau\omicron\kappa\iota\nu\epsilon\iota\tau\alpha\iota$  - lit. move upwards and downwards] the chest according as the breath is admitted or expelled [ $\delta\epsilon\kappa\eta\omicron\mu\acute{\epsilon}\nu\omicron\nu\tau\omicron\pi\nu\epsilon\acute{\upsilon}\mu\alpha\kappa\alpha\iota\epsilon\chi\iota\acute{\epsilon}\nu\tau\omicron\nu$  - lit. receive and expel the breath]. (Aristotle, *On Respiration*, part 22, trans. G. R. T. Ross)

The inward passage of the air is called respiration, the outward expiration, and this double movement goes on continuously [ $\kappa\alpha\iota\alpha\epsilon\iota\delta\epsilon\tau\omicron\upsilon\tau\omicron\gamma\acute{\iota}\nu\epsilon\tau\alpha\iota\sigma\upsilon\nu\epsilon\kappa\eta\omicron\varsigma$ ] just so long as the animal lives and keeps this organ in continuous motion [ $\kappa\alpha\iota\kappa\iota\nu\epsilon\iota\tau\omicron\upsilon\tau\omicron\tau\omicron\mu\upsilon\tau\omicron\nu\sigma\upsilon\nu\epsilon\kappa\eta\omicron\varsigma$ ]; it is for this reason that life is bound up with the passage of the breath outwards and inwards [ $\kappa\alpha\iota\delta\iota\acute{\alpha}\tau\omicron\upsilon\tau\omicron\epsilon\nu\tau\omicron\iota\alpha\nu\alpha\pi\nu\epsilon\acute{\iota}\nu\kappa\alpha\iota\epsilon\kappa\pi\nu\epsilon\acute{\iota}\nu\epsilon\sigma\tau\iota\zeta\eta\nu$ ]. (Aristotle, *On Respiration*, part 27, trans. G. R. T. Ross)

The lungs constitute the primary cooling organ of the heart which embodies the "hot substance" in animals. Respiration, heart pulsations and even palpitations are therefore in some ways connected by the circulation of vital heat, but they are also to be distinguished.

In connection with the heart there are three phenomena, which, though apparently of the same nature, are really not so, namely palpitation, pulsation, and respiration [ $\lambda\upsilon\acute{\alpha}\nu\alpha\iota$   $\alpha\epsilon\iota\sigma\mu\acute{o}\varsigma$   $\kappa\alpha\iota$   $\alpha\lambda\epsilon\iota\sigma\mu\acute{o}\varsigma$ ]. (Aristotle, *On Respiration*, part 26, trans. G. R. T. Ross, my mod.)

Although the distinction between the two vascular systems, the venous and arterial, will not be worked out until the generation after him, Aristotle is apparently the first to depict pulsation as a constant in all blood vessels and to suggest its connection with the heart. In his *Historia animalium*, he says that "the blood in animals pulsates [*ἄεϊμῆ - sphúzei*] in all the blood vessels throughout [the body] at once" (*Historia animalium*, 3.19.521a, comments and quote by van Staden, 1989, p. 269).

Contrary to the Hippocratic physicians, who see the pulse as an unnatural motion caused by disease or emotion, Aristotle considers it a natural and continuous physiological motion. According to him, the heart produces the blood from the fluid supplied by the food. Then, under the influence of heat, the blood volume expands and, as in the throbbing of an abscess or, more precisely, in boiling water, the surplus is more or less regularly discharged. But again, he makes no mention of rhythm in these passages.

[The pulsation accompanying] the heart [*ἄεϊμῆ τῆς καρδίας - sphúxis tês kardías*], which, as can be seen, goes on continuously, is similar to [the throbbing of] abscesses [*ἁμῶν ἄεϊμῆ - homoía phúmasín estin*]. That, however, is accompanied by pain, because the change produced in the blood is unnatural, and it goes on until the matter formed by concoction is discharged. There is a similarity between this phenomenon and that of boiling; for boiling is due to the volatilization of fluid by heat and the expansion consequent on increase of bulk. But in an abscess, if there is no evaporation through the walls, the process terminates in suppuration due to the thickening of the liquid, while in boiling it ends in the escape of the fluid out of the containing vessel. (Aristotle, *On Respiration*, 20.479b-480a, trans. G. R. T. Ross, my mod.)

Like his predecessors, Aristotle thus refers to the pulse with the terms *sphúxis*, *sphugmys* or *sphúzein*. But only the blood vessels (*phlébes*) pulsate (*sphúzousin*), due to their "connection with the heart."

In the heart [*ἐν τῇ καρδίᾳ - En dè têt kardíai*] the beating is produced [*ποιεῖ - poieî sphugmyn*] by the heat expanding the fluid, of which the food furnishes a constant supply. It occurs when the fluid rises to the outer wall of the heart, and it goes on continuously; for there is a constant flow of the fluid that goes to constitute the blood, it being in the heart that the blood receives its primary elaboration. That this is so we can perceive in the initial stages of generation, for the heart can be seen to contain blood before the veins become distinct. This explains why pulsation [*ἄεϊμῆ - sphúzei*] in youth exceeds that in older people, for in the young the formation of vapor is more abundant. [All the blood vessels pulsate] [*ἅεϊμῆ - sphúzousin*] and do so simultaneously with each other, owing to their connection with the heart. [Since the heart is always in motion [*κινεῖται - Kineî d'aeî hôste*], so are the [blood vessels], and their motion keeps running continuously and simultaneously as long as the heart moves [*κινεῖται - hyste kinei*] [...]. [Pulsation, then, is the evaporation [volatilization; pneumatization] of the heated moisture.] (Aristotle, *On Respiration*, 20.479b-480a, trans. G. R. T. Ross, my mod.)

Both heart-beat and pulse are, in Aristotle's view, normal and constant bodily functions, and they both result from the pneumatization or vaporization of food derivatives which are in liquid form. However, as in Hippocratic writings and in Plato, there is no sign in Aristotle of any use of *ῥυθμῶν - rhuthmōn - rhythm* or *ῥυθμοειδῶν - rhuthmoeidēs -*

*rhythmical* to refer to them.

## Respiration with Rhythm - Peripatetic School's Problems (3rd c. BC)

The *Ἀζήτων Ἔκθεσις* - *Problēmata* - *Problems*, which is a pseudo-Aristotelian collection of questions and answers gradually assembled by members of the peripatetic school since possibly the end of the 4th century and more probably the 3rd century, is one of the first texts where the term *rhuthmys* is used to refer to respiration. However, the gap between the Aristotelian sophisticated rhythmic analyses developed in *Rhetoric* and *Poetics* and the gross definitions given in passing in this collection suggests that the issue of rhythm was not any more considered as central in the school and that the few uses that we find in it are borrowed from other sources, most probably medical writings.

While endorsing, as we shall see, the Platonic definition of rhythm as "order of movement," *The Problems* demonstrate a typical Aristotelian interest for empirical observation. In Book 19, the Platonic question of the relation between musical rhythms, melodies and *ἦθος* - *êthos* - disposition, character, is addressed as a fact granted by observation. But the Aristotelian author (borrowing from Aristotle, cf. *Politics*, 8.1340a) divides and reverses the issue: he asks why *music* but not *color nor smell nor flavor*, instead of *influencing* one's character, can *represent* what we call psychological moods or what the Greeks called ethical character? As melody, rhythm is a movement in sound that has a "likeness" to ethical character. It is not clear whether rhythm is here only a movement or if it is presupposed to be, as we shall see in Book 5, a more or less regular repetition of alternate times, but the association with melody suggests that it is the case.

Why does what is heard, alone of perceptible objects, possess ethical character [*ἦθος ἕκθει* - *êthos êkhei* - lit. bears, carries character]? Indeed, even if a melody is without words, it nonetheless possesses ethical character [*ἦθος ἕκθει ἦθος* - *homôs êkhei êthos*]; but neither color nor smell nor flavor possess it. Is it because [what is heard] alone possesses movement, though not that which the sound moves in us? [...] This movement has a likeness [to ethical character] both in the rhythms and in the arrangement of high and low notes, not in their mixture. But consonance has no ethical character. (*Problems*, Book 19, 919b, trans. Robert Mayhew)

Why do rhythms and melodies, which are sound, resemble ethical character, while flavors do not, nor colors and odors? Is it because they are movements, as actions too are? Now activity is ethical and produces ethical character, but flavors and colors do not act in this way. (*Problems*, Book 19, 920a, trans. Robert Mayhew)

In another occurrence, the author claims that "we enjoy rhythm because it has a recognizable and orderly number and moves us in an orderly fashion." Yet, according to Aristotle's more earthly orientation, eurhythmia is no longer imitation of the perfect heavenly movements but results from moving according to human nature, i.e. regularly and without excess. "Exercising and drinking and eating in an orderly fashion" helps us to "preserve and improve our nature and power," whereas disorderly behavior "ruins and deranges it." Rhythmicity, defined on a Platonic basis, becomes medically beneficial regularity.



Why does everyone enjoy rhythm and melody [ῥυθμοὶ καὶ μέλει] and in general all concords [ἁρμονίαι - *sumphóniais*]? Is it because we naturally enjoy natural movements? Now a sign of this is that children enjoy these straightaway from birth. And we enjoy different types of melody because of habituation. But we enjoy [rhythms] [ῥυθμοί] because [they have] a recognizable and orderly number and [move] us in an orderly fashion; for orderly movement is naturally more akin to us than disorderly, and so is more natural. And here is an indication of this: by exercising and drinking and eating in an orderly fashion we preserve and improve our nature and power, but in a disorderly fashion we ruin and derange it: for diseases are movements of the order of the body not in accordance with nature. But we enjoy concord, because it is a mix of opposites standing in proportion to one another. Therefore proportion is an order that is naturally pleasant. (*Problems*, Book 19, 920b-921a, trans. Robert Mayhew, my mod.)

Whereas the two previous series of occurrences were still taking part in quite traditional musical and ethical discussions, adding a more empiricist view to it, the last occurrence of the term *rhuthmys* in the *Problems* is more innovative. Under the influence of Plato and Aristotle, the term rhythm is still defined as what is "measured by definite [or divided] movement." But it is used to denote the regular respiration of runners when they jog without excess: "As soon as they begin to run they breathe, and as their breathing is coming regularly because it is measured by regular movement, it produces a rhythm." When someone is sitting or walking slowly, the rhythm of his breath is difficult to observe; but it is the same if someone runs to fast. Rhythm here clearly means a perceptible regular repetition of alternate times.

Why do those who are not running under great strain breathe rhythmically [ $\frac{1}{2}\text{ } \ddot{\alpha}\text{ } \frac{1}{4}\text{ } \div \frac{1}{2}\text{ } \ddot{\alpha}\text{ } \frac{1}{2}\text{ } - \dot{\iota}\text{ } \ddot{\alpha}\text{ } \ddot{\alpha}\text{ } \frac{1}{2}\text{ } - \acute{\epsilon}\text{ } \eta\text{ } \tau\acute{o}\iota$  *rhuthmôî anapnéousin*]? Is it because all rhythm [ $\dot{\alpha}\text{ } \dot{\alpha}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \times\text{ } \dot{\alpha}\text{ } - \text{pâs } rhuthm\acute{o}s$ ] is measured by definite movement [ $\dot{\alpha}\text{ } \dot{\alpha}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } - \frac{1}{2}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \mu\text{ } \ddot{\alpha}\text{ } \mu\text{ } \ddot{\alpha}\text{ } \ddot{\alpha}\text{ } \pm\text{ } \acute{o}\text{ } \frac{1}{2}\text{ } \textcircled{\alpha}\text{ } \mu\text{ } \acute{\alpha}\text{ } - \acute{h}\acute{o}\text{ } \rho\acute{i}\text{ } \sigma\text{m}\acute{\epsilon}\text{ } \eta\acute{\epsilon}\text{ } \iota$  *metreîtai kinêsei* - lit. by divided movement], and the kind of movement that runners make is regular? So as soon as they begin to run they breathe, and as their breathing is coming regularly because it is measured by regular movement [ $4\text{ } \ddot{\alpha}\text{ } \ddot{\alpha}\text{ } \acute{o}\text{ } \frac{1}{2}\text{ } \textcircled{\alpha}\text{ } \mu\text{ } \frac{1}{4}\text{ } \mu\text{ } \ddot{\alpha}\text{ } \mu\text{ } \ddot{\alpha}\text{ } \ddot{\alpha}\text{ } \pm\text{ } \acute{o}\text{ } - \acute{i}\acute{s}\acute{\epsilon}\acute{i}$  *kinêsei metreîstai*], it produces a rhythm [ $\dot{\alpha}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \times\text{ } \frac{1}{2}\text{ } \dot{\alpha}\text{ } \dot{\iota}\text{ } \mu\text{ } \ddot{\alpha}\text{ } \frac{1}{2}\text{ } - rhuthm\acute{o}\text{ } \rho\acute{o}\text{ } \epsilon\acute{i}\eta$ ]. Or is it because all breathing without qualification is regular in those who employ it naturally and do not hold their breath? So in those sitting or walking, as the movement of the body is moderate, the rhythm [ $\dot{\alpha}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \times\text{ } \dot{\alpha}\text{ } - \text{ho } rhuthm\acute{o}s$ ] is not obvious; while in those running intensely, as our perception cannot follow the movement, we are unable to observe the rhythm of the breathing. But in the one running moderately, the movement, making the measure of breathing perceptible, reveals its rhythm [ $\ddot{\alpha}\text{ } \times\text{ } \frac{1}{2}\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \times\text{ } \frac{1}{2}\text{ } - \tau\acute{o}\text{ } \eta\text{ } \rho\acute{h}\text{u}\text{ } \theta\text{m}\acute{o}\text{ } \eta$ ]. (*Problems*, Book 5, 882b, trans. Robert Mayhew)

Although rhythm does not play a great role in *The Problems*, this collection constitutes an important token of the spreading and transformation of the concept during the late 4th and 3rd centuries BC, even though we are not sure of the beginning of their assembly. It is one of the first times, at least to my knowledge, that rhythm is used outside dance, music and poetry and translated to another field, sc. physiology, to refer to the respiration.

## Pulse with Rhythm - Peripatetic Anonymus' *On Breath* (first half or mid-3rd cent. BC)

A similar conceptual extension, this time concerning the pulse, seems to take place in another Peripatetic text of the same period:  $\mu\text{ } \acute{\alpha}\text{ } \nu\text{ } \dot{\alpha}\text{ } \frac{1}{2}\text{ } \mu\text{ } \dot{\alpha}\text{ } \frac{1}{4}\text{ } \pm\text{ } \dot{\alpha}\text{ } \dot{\iota}\text{ } \dot{\alpha}\text{ } - \text{Peri } pne\acute{u}\text{m}\acute{a}\text{t}\acute{o}\text{s} - \text{On Breath}$  often referred to by its Latin name *De spiritu*. In modern times, its ancient attribution to Aristotle has been virtually unanimously rejected [3], nevertheless most or all of it has been acknowledged to be an early work of the Peripatetic school, possibly connected with Theophrastus (ca. 371 - ca. 287 BC) or Strato of Lampsacus (ca. 335 - ca. 269 BC) [4].

I won't discuss the doctrines evoked by the treatise for their own sake: the method of nutrition of the vital breath ( $\dot{\alpha}\text{ } \frac{1}{2}\text{ } \mu\text{ } \acute{\alpha}\text{ } \frac{1}{4}\text{ } \pm\text{ } - \text{pne}\acute{u}\text{m}\acute{a}$ ) a concept borrowed from Aristotle either by the air inspired by the lungs or internally by the blood. I won't neither discuss the various influences that can be traced in it: specialists do agree on the Aristotelian background of the author but they diverge on the exact interpretation of his differences with Aristotle, particularly whether the author was deeply influenced by Erasistratus (ca. 304 - ca. 250 BC) (Jaeger), or had loose connection with his teaching (Gregoric & Lewis), or clearly rejected it (Federspiel). Once again, my only interest is to assess how this mid-3rd century member of the Peripatetic school made use of the term *rhuthmys*, whatever his specific physiological beliefs were.

The author of the *De spiritu* sometimes uses *rhuthmys* and its verbal extension *rhuthmízousai* in a very traditional way. These words then mean respectively "shape" and "to give shape."

For different results are achieved by fire in the work of the goldsmith, the coppersmith, the carpenter, and the cook though, perhaps, it is truer to say that the arts themselves achieve these different results, for that by using fire as an instrument they soften, liquefy, and desiccate substances, and some they [shape] [ $\frac{1}{2}\epsilon\ \acute{\rho}\ \sigma\pm v$   $\acute{\alpha}\acute{\alpha}\ \frac{1}{4}w\ \epsilon\ \acute{\alpha}\acute{\alpha}\ \pm^1$  - *énia dè kai rhuthmízousai*]. [...] while the crafts use the fire merely as an instrument, nature uses it as a material as well. Certainly no difficulty is involved in this; but rather it is remarkable that nature, who employs the instrument, is herself an intelligent agent, who will assign to objects their proper [shape] [ $\rho\pm v$   $\acute{\alpha}\chi\frac{1}{2}\ \acute{\alpha}\acute{\alpha}\ \frac{1}{4}\times\frac{1}{2}$  - *kai tòn rhuthmòn*] together with the visible effects of her action : for this is no longer a function either of fire or of breath. (Anonymus, *De spiritu*, 485a-485b, trans. J.F. Dobson, my mod.)

But the author also employs *rhuthmys* in a more innovative way to refer to the pulse (*sphugmys*) which is one more piece of evidence that proves that the text cannot be attributed to Aristotle and must have been written by one of his successors in the Peripatetic School [5].

He starts from Aristotle's theories: contrary to early Hippocratics' view, the pulse is a natural physiological motion. However, it is not only a side effect of the internal heat, as Aristotle claimed; it constitutes a primary "activity" or function of the heart ( $\frac{1}{2}\acute{\alpha}\acute{\alpha}\mu^1\pm$  - *enérgeia*).

Respiration begins when the young is separated from the mother; the reception of nutriment, and nutrition, both while the embryo is forming and after it is formed; but the pulsation [ $A\ \acute{\rho}\ \acute{\alpha}\acute{\alpha}\ \acute{\alpha}\ \frac{3}{4}\times\acute{\alpha}$  - *ho dè sphugmys*] at the earliest stage [ $\frac{1}{2}\ \acute{\alpha}\ \acute{\alpha}\ \acute{\alpha}$  - *en tēi arkhēi*], as soon as the heart begins to form, as is evident in the case of eggs. So the pulse comes first [ $e\acute{\alpha}\acute{\alpha}\mu\ \pm U\acute{\alpha}\ \acute{\alpha}\acute{\alpha}\ \acute{\alpha}$  - *hōste hautē prôtē*], and resembles an activity [ $\rho\pm v$   $\epsilon\ \acute{\rho}\ \mu\ \frac{1}{2}\ \frac{1}{2}\mu\acute{\alpha}\acute{\alpha}\mu w^3\ \acute{\alpha}\ \frac{1}{2}v$  - *kai éoiken energeíai tini*] and not an interception of the breath, unless that also can conduce towards its activity [ $\acute{\alpha}\acute{\alpha}\times\acute{\alpha}\ \acute{\alpha}\ \frac{1}{2}\ \frac{1}{2}s\acute{\alpha}\acute{\alpha}\mu^1\pm\frac{1}{2}$  - *pròs tēn enérgeian*]. (Anonymus, *De spiritu*, 483a, trans. J.F. Dobson)

Moreover, the pulse, which is to be differentiated "from the other motions," i.e. respiration and maybe palpitation, "extends to the other parts" of the body. This differentiation is motivated by the initial question of the treatise: does the blood, and not the respiration, bring nutrition to the *pneûma*. Simultaneously, the author still refers to Aristotle's doctrine of internal heat and "bubbling" blood from the heart.

The pulse [ $\acute{\alpha}\acute{\alpha}\ \acute{\alpha}\ \frac{3}{4}\times\acute{\alpha}$  - *sphugmys*] is something peculiar and distinct from the other motions and in some respects may be seen to be contingent, assuming that when there is an excess of warmth in a fluid, that fluid which is evaporated must set up a pulsation owing to the air being intercepted in the interior, and pulsation must arise in the originating part and in the earliest stage, since it is inborn in the earliest parts. For it arises firstly and in the greatest degree in the heart, and thence extends to the other parts. Perhaps this must be an inseparable consequence of the essential nature underlying the living creature, which is manifested when the creature is in a condition of activity. (Anonymus, *De spiritu*, 482b, trans. J.F. Dobson)

Usually the pulse "remains the same and unchanged" but it may become "irregular and spasmodic owing to certain bodily affections and in consequence of fear, hope, and anguish affecting the soul." Whereas Aristotle used two different terms *pédésis* for the heart's rapid motion in the emotional state of fear and *sphugmys* for the constant motion of the heart and the veins the *De spiritu* innovates, in fact as Herophilus a few years before, by employing the same term *sphugmys* for both kinds of motion.

That the pulse [*ΑΔΕΑ*<sup>3/4</sup>*γΑ* - *ho ΑΔΕΑ*<sup>3/4</sup>*γΑ*] has no connection with the respiration [*1/2±Α*<sup>1/2</sup>*ι*<sup>1/2</sup> - *anapnoên*] is shown by the following indication whether one breathes [483a] quickly or regularly [*A*<sup>1/4</sup>*±x*<sup>1/2</sup> - *homalôn*], violently or gently, the pulse [*ΑΔΕΑ*<sup>3/4</sup>*xΑ* - *sphugmys*] remains the same and unchanged [*E*<sup>1/4</sup>*ι*<sup>1</sup>*ι*<sup>Α</sup> <sup>0±v</sup> *A* <sup>±P</sup>*ΑγΑ* - *hymoios kai ho autys*], but it becomes irregular and spasmodic owing to certain bodily affections and in consequence of fear, hope, and anguish affecting the soul. (Anonymus, *De spiritu*, 482b-483a, trans. J.F. Dobson)

This series of arguments leads the author of *De spiritu* to finally consider whether, contrary to Aristotle who thought that only the veins pulsate, also arteries do, and, if this is the case, whether they pulse "with the same rhythm and regularity" most likely meaning: as the heart and maybe the veins. Borrowing from Erasistratus, he immediately adds that it "does not appear to be so in the case of parts widely separated," which implies that some arteries and veins do not pulsate at the same time, due possibly to their distance to the heart since the author rejects the idea of autonomous motions.

Next we ought to consider whether the pulse occurs also in the arteries and with the same rhythm and regularity [as in the heart] [<sup>0</sup> <sup>1/2</sup> *A* <sup>±P</sup>*ΑxΑ* <sup>b</sup><sup>1/2</sup> <sup>1/2</sup> *â*<sup>1/2</sup> <sup>1/4</sup> <sup>±v</sup> *A*<sup>1/4</sup>*±x*<sup>1/2</sup>*Α* - - *kân ho autòs ôn en rhuthmôi kai homalòs êj*]. This does not appear to be so in the case of parts widely separated. (Anonymus, *De spiritu*, 483a, trans. J.F. Dobson)

Gregoric and Lewis recently proposed a new translation of this passage: "We must examine whether the *art riai* also pulsate and whether, having the same rhythm [as the pulse in the heart and *h art ria*], [the pulse in the *art riai*] is also even." They think that the term *A*<sup>1/4</sup>*±x*<sup>1/2</sup>*Α* - *homalòs* - *even* refers to "the question of whether the heart and the *art riai* expand and contract simultaneously or alternately."

The evenness may, perhaps, refer to the question of whether the heart and the *art riai* expand and contract simultaneously or alternately (*1/4*<sup>±x</sup><sup>1/2</sup> *ΑΔΕ*<sup>1/2</sup>): while Erasistratus believed that the *art riai* expand when the heart contracts (because it pushes the *pneuma* into the *art riai* when it contracts), Herophilus and Galen claimed that the arteries expand together with the heart's expansion. (Gregoric & Lewis, 2015, p. 165, n. 28)

This is an interesting point but it presupposes that *rhuthmys* might already mean "regular beat," and that consequently the question would concern only the synchronicity of the arterial regular beat with that of the heart. But one may doubt that the term has here such a definite and "modern" meaning. As in the *Problems*, it already clearly involves some repetition of alternate times, but it does not imply their strict regularity. And that is why, in my opinion, the author feels compelled to complete his characterization of the pulse with the term *A*<sup>1/4</sup>*±x*<sup>1/2</sup>*Α* - *homalòs*, that should be therefore translated as "regular or even by themselves" and not "synchronous or even with the heart beat."

As a matter of fact,  $\frac{1}{2} \text{ } \acute{\alpha} \acute{\alpha} \frac{1}{4} \div$  - *en rhuthmôî* an expression, it is worth noticing, that was already used in the *Problems* to refer to respiration was an expression often used to refer to dance or to military marching. It meant "in time" and described an alternate motion that was reproduced simultaneously by a group of dancers or soldiers. The Liddell-Scott-Jones Dictionary reads " $\frac{1}{2} \text{ } \acute{\alpha} \acute{\alpha} \frac{1}{4} \div$  - *en rhuthmôî* = in time, of dancing, marching, etc." It quotes Plato's *Laws* (Lg.670 b) : " $\text{ } \acute{\alpha} \acute{\alpha} \frac{1}{4} \div$  - *baínein en rhuthmôî* = being drilled"; and Thucydides (Th.5.7): " $\frac{1}{4} \mu \acute{\alpha} \rho \acute{\alpha} \acute{\alpha} \frac{1}{4} \div \acute{\alpha} \acute{\alpha} \text{ } \acute{\alpha} \acute{\alpha} \frac{1}{4} \div$  - *metà rhuthmoû baínontes*" = stepping in time.

*En rhuthmôî* is then clearly used in *De spiritu* as a metaphor comparing the motions of the various arteries with those of dancers or soldiers. In this sense, it seems lagging a little behind the progress of medicine in the first half of the 3rd century. It has not yet the sense of regularity that has already come to the foreground with Herophilus. This seems to prove that in the Peripatetic school the first extensions of the concept of *rhuthmys* out of poetry, music and dance theory towards life science have not been the result of an autonomous doctrinal change but reflect most probably the influence of the Alexandrian school of medicine

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[1] On Diocles of Carystus see Philip van der Eijk, 2000.

[2] For the next paragraphs on Praxagoras I used mainly *Paulys Realencyclopädie der classischen Altertumswissenschaft*, Band XXII, 2 (1954), sp. 1735-1743. See also Lewis, Orly. 2017 and van Staden, 1989, p. 270.

[3] Although re-attribution to Aristotle has recently been attempted by Bos and Ferwerda (2008).

[4] In his classic 1913 study, Werner Jaeger situated the treatise in the middle of the third century BC. More recent scholarship tends "to favor a slightly earlier dating" (Gregoric & Lewis, 2015, p. 166). "The author of the *On Breath* remains unknown. All that can be affirmed with certainty is that it is not a physician, but a Peripatetician contemporary with Erasistrate or slightly posterior, i.e. from the first half or the middle of the 3rd century BC. The conciseness and obscurity of his work suggest that he dealt with subjects already known by readers of his time; from this it can be inferred that the main theses of the new medicine were known and discussed in the Peripatetic school in the 3rd century." (Federspiel & Guillaumin, 2017, my trans.)

[5] Pavel Gregoric and Orly Lewis have recently reviewed all pieces of evidence that speak against an attribution of the treatise to Aristotle. They refer to the pulse but do not discuss specifically the use of *rhuthmys* (Gregoric & Lewis, 2015).