

Plants' Bodies and the Question of Vegetal Respiration in Early Greek Philosophy

Abstract

This essay pursues the question of vegetal respiration in Presocratics' doctrines in contrast to Aristotle's categorical circumscription of this vital process to the blooded animals. It finds that epithelial respiration in DK31 B100 is central to Empedocles' conception of plants' breathing, linked to their fructification, deciduousness, and overall life preservation. It also discusses plants' respiration in relation to their body temperature in Menestor, then, concludes by analyzing Democritus' psychological doctrine, arguing that the intake of fiery atoms pertained to all living beings, plants included.

Aristotle's study of comparative anatomy has been crucial in denying plants a series of living functions that in his physical doctrine characterized the more complex life of animals. Plants' basic earthy constitution made them unable to sense,¹ and, equipped with simply articulated bodies, they merely absorbed liquid food from the earth. By contrast, animals possessed sensation and engaged more actively in the process of nutrition. Differently from plants, they felt desire, took in and processed their food (dry and liquid)—in successive stages, from the mouth to the stomach—and expelled it. These were not the only differences, however. For Aristotle plants did not breathe either. In *On Respiration* this denial is implicit in the circumscription of respiration to

¹ In *PA* 2 Aristotle identifies three, teleologically-related layers of composition in animals' bodies: of elements, of uniform parts and non-uniform ones. The elements compose the uniform parts (i.e., the blood, tissues, bones and other organic ingredients of animals' bodies), which in turn compose the non-uniform ones (i.e., nose, eyes, members and similarly well-defined parts), all working together in a structured unity (i.e., the body) for the sake of the complex action (πολυμερής πράξις) that is life (Aristot. *PA* 2 646a29-646b10; see Lennox 2001). In Aristotle's doctrine the fundamental difference between animals and plants lies in the fact that, due to their souls, plants' have much simpler bodies—at all levels. At the elemental level of composition they are constituted prevalently of earth, which confers on them a minimal internal heat and leads to a minimally articulated body both in terms of uniform and non-uniform parts, and ultimately to the incapacity to sense; for plants' earthy constitution and its consequences in terms of their lack of the sense of touch, see *DA* 2 435a17-435b3.

the blooded animals equipped with the nose/lung apparatus (*Resp.* 470b14-22) while in *On Youth and Old Age* it is made explicit in the claim that plants simply cool off both by the exposure to their surrounding (τὸ περιέχον, i.e., air), and the absorption of liquid food. No intake of air is involved (*Aristot. de Iuv.* 470a19-23). In restricting the possession of respiration to a limited category of animals, Aristotle is arguing against some Presocratics—among whom Empedocles and Democritus—who, he tells us, attributed respiration to “all animals” (πάντα) (*Resp.* 470b10-1; 470b30-1) due to a lack of knowledge of animals’ internal anatomy (*Aristot. Resp.* 471b23-7).

Among the Presocratics, Diogenes of Apollonia, too, rejected the notion that plants are capable of respiration and, as later for Aristotle, he too based this denial on anatomical reasons: because they had no cavities allowing the intake of air, Diogenes argued, plants were completely devoid of intelligence.² Humans and the other animals, by contrast, lived by breathing and possessed some form of νόησις (mental activity),³ the degree of which depended on the quality of the air inhaled and whether or not the flesh of their bodies let the air circulate. For instance, although birds breathed warm and intelligence-conducive air, they were still witless creatures because their flesh was compact and prevented the air from diffusing inside the body. But though Diogenes seems to have been the first to mark a radical discontinuity between plants and animals, based on anatomical differences, hence anticipating Aristotle’s most authoritative divide which attributed to plants the mere capacity for nutrition, growth, and reproduction,⁴ for the other Presocratics (those who were interested in botany)

² DK 64 A 19/Thph. *de Sens.* 44 (As for plants because they have no cavities and do not welcome the air, they are entirely devoid of thinking). Unless otherwise indicated, all translations of Presocratic philosophers are from the Loeb edition by Laks and Most (2016).

³ DK 64 B 4/Simpl. *In Phys.* p. 152.18-21 (ἄνθρωποι γὰρ καὶ τὰ ἄλλα ζῷα ἀναπνέοντα ζῶει τῷ ἀέρι καὶ τοῦτο αὐτοῖς καὶ ψυχὴ ἐστὶ καὶ νόησις, ὥς δεδηλώσεται ἐν τῇδε τῇ συγγραφῇ ἐμφανῶς, καὶ ἐὰν τοῦτο ἀπαλλαχθῇ, ἀποθνήσκει καὶ ἡ νόησις ἐπιλείπει). For the inclusive meaning of νόησις, see Laks 2008, 79.

⁴ In fact, there is reason to believe that Diogenes might have contributed to Aristotle’s doctrine on plants (and his implicit disagreement with Plato): the extensive account of Diogenes’ conception of blood

plants represented a form of animal life: no radical differentiation existed. Indeed, as it has been recently argued, plants shared with animals the same origin and hence a similar constitution,⁵ and possessed (some forms of) sensation and desire. Given such continuity between plants and animals, this study aims to address the question of vegetal respiration and to illuminate a so-far neglected aspect of plants' life prior to Aristotle by bringing together a number of overlooked texts including those of the obscure Menestor of Sybaris.⁶ By situating them in a larger framework that encompasses Empedocles and Democritus, this study ultimately reveals these Presocratics' shared attention to plants' relationship to their environment as crucial to vegetal life and processes. But further, it also brings to the fore Theophrastus' doxographical interest in the botanical works too. For if it is well-known that Theophrastus engaged with Presocratic doctrines in *On the Senses* and a lost eighteen-volume treatise,⁷ this essay shows such engagement also at specific points of his discussion in *On the History of Plants* and *On the Causes of Plants*.

1. Empedocles: Vegetal Respiration, Deciduousness and Fructification

Much of the evidence about the Presocratics' conceptions of respiration is preserved in Aristotle's short treatise *On Respiration*. Among the several criticisms Aristotle raises against his predecessors—the lack of experience and (for some) the

circulation in *History of Animals* shows that Aristotle was quite familiar with Diogenes' ideas (*HA* iii 511b31-513b11).

⁵ See Zatta's discussion in "Early Greek Philosophy on the Question of Life: Plants' Physiology and Life from Presocratics and Aristotle," forthcoming in *Archives Internationales de l'Histoire des Sciences* in December 2022.

⁶ Theophrastus is our only source on Menestor, whose doctrinal tenets are discussed from various focuses, in Capelle 1961, Longrigg 1965, Viano 1992, Repici 2000, Zhmud, 2008. Among these authors, however, only Longrigg mentions the respiration of the ivy (see below) in the context of his interpretation of Empedocles' belief, reported by Aristotle (*Resp.* 477a32/DK 31 A 73), that fishes migrated from earth to water on account of their fiery nature.

⁷ For Theophrastus' *On the Senses*, see Baltussen 1992, 1-19; for the lost treatise and the question involving its title, whether *Opinions of Natural Philosophers* or *Natural Opinions*, and the problem-defining use of doxography, Mansfeld 1992, 63-111.

neglect of the purpose of respiration⁸—there is also the problematic claim that “all animals breathe” without any detailed account of which animals in fact do so⁹ and, we may add, with the category of ζῷα pointing to the inclusion of plants. The oldest piece of evidence about respiration as a phenomenon common to all living beings is fragment 100 of Empedocles, preserved in Aristotle’s discussion¹⁰:

ὥδε δ’ ἀναπνεῖ πάντα καὶ ἐκπνεῖ· πᾶσι λίφαιμοι
σαρκῶν σύριγγες πύματον κατὰ σῶμα τέτανται,
καί σφιν ἐπὶ στομίῳις πυκναῖς τέτρηνται ἄλοξιν
ρίνων ἔσχατα τέρθρα διαμπερές, ὥστε φόνον μὲν
κεύθειν, αἰθέρι δ’ εὐπορίην διόδοισι τεμῆσθαι. 5
ἔνθεν ἔπειθ’ ὅπῳταν μὲν ἀπαΐξῃ τέρεν αἷμα,
αἰθήρ παφλάζων καταΐσσεται οἷδατι μάργῳ,
εὔτε δ’ ἀναθρόσκη, πάλιν ἐκπνέει [...]

It is in this way that all [scil. probably: living beings] inhale and exhale: for all
Channels of flesh, which the blood leaves, extend to the surface of their bodies;
And at the openings, the furthest limits of their skin (*rhinôn*)
Are perforated through and through with dense furrows, so that the blood
Lies hidden, while easy access is cut by these passages for the air (*aithêr*) 5
When from here the delicate blood then rushes backward,
The air (*aithêr*), boiling, rushes after it in a raging surge.¹¹

⁸ Aristotle is thinking, among others, about Empedocles when he remarks that of those Presocratics who admitted animals’ respiration some did not discuss its causes. By contrast, as we will see in the last section of this paper, Democritus did point to a cause for respiration, i.e., the pressure of the external air upon the living being (see Aristot. *Resp.* 471b30-472a25/ DK 68 A 106, discussed on pp. 21-23 below; cf. *DA* i 404a1-17).

⁹ Aristotle raises this critique first at the beginning of his treatise (*Resp.* 470b10-1), and then in the successive discussion of Democritus, Anaxagoras and Diogenes of Apollonia (470b28-32), while he complains that Empedocles did not make clear whether all animals breathe (473a15-7). It bears noting that Aristotle attributes to the Presocratics an exclusive conception of ζῷα, namely one in which animals are radically different from plants. As we have seen above, however, such a conception may well suit Diogenes, who groups man and animals together as breathing creatures other than plants, but it does not apply to Empedocles and Democritus for whom plants were in fact ζῷα. Suffice here to recall that Empedocles is said to have claimed that “trees were the first living beings (ζῷα) to rise up out of the earth, before the sun began its circular movement and before the day and night were separated.” DK 31 A 70/Aët. v.26.4 (Εμπεδοκλῆς πρῶτα τὰ δένδρα τῶν ζῴων ἐκ γῆς ἀναδύναί φησι πρὶν τὸν ἥλιον περιπλωθῆναι καὶ πρὶν ἡμέραν καὶ νύκτα διακριθῆναι); for Democritus, see section 3 below. Still Plato’s *Timaeus*, which revisits the natural philosophy of the Presocratics, offers a definition that echoes earlier conceptions: “For everything, in fact, which partakes of life may justly and with perfect truth be termed a living creature.” Plat. *Timaeus* 77a, transl. by R. G. Bury (πᾶν γὰρ οὗν ὃ τι περ ἂν μετὰσχη τοῦ ζῴου, ζῶον μὲν ἂν ἐν δίκῃ λέγοιτο ὀρθότατα).

¹⁰ As Thivel remarks, this is also the oldest piece that set in opposition the verbs ἀναπνεῖν ἐκπνεῖν (2005, 245).

¹¹ DK 31 B 100, lines 1-8/Arist. *Resp.* 473b9-16. There has been a scholarly controversy regarding the meaning of ῥίνων which Aristotle takes as referring to the nostrils (as genitive plural of ῥίς); in the fragment, though, its primary meaning is (the pores of) the skin (ῥινός), while it also points to the respiration through the “bigger pores” constituted by the nostrils; see Wright 1981 245-6; cf. Bollack, 1969, 246-7 and Worthen 1970, 523-8. Other scholars, however, still endorse Aristotle’s reading (see, for instance, Booth 1960, 10-1, Rossetti 2004, 162-85). Here I side with Wright, whose position is further corroborated by Aëtius’ testimony of the first breath of the first living being (Aët. iv.22.1/DK 31 A 74), also discussed below.

In this fragment Empedocles' statement about the universality of breathing (ἀναπνεῖ πάντα) is followed by his description of its mechanism. Respiration consists in an oscillatory movement involving the blood and the external air via body channels that stretch up to the surface of the skin. When the blood recedes inward, leaving the channels bloodless, the air enters through the epithelial pores and is successively expelled by the resurgent blood. The fact that Empedocles mentions the blood while attributing respiration to all things should not be taken as a contradiction. Fr. 82 indicates that Empedocles considered living beings' bodies through analogies,¹² and just as the feathers, scales and hairs of blooded animals corresponded to the leaves of a plant, so the blood could have its vegetal analogues. Also, in fr. 79, the statement "tall trees bearing eggs, the olive first" (DK 31 B 79/Aristot. *GA* 1.731a5)¹³ shows a correspondence between fruit (or seed) and eggs as organic principles of generation and life. Trees were able to reproduce themselves through seeds as animals did through the eggs.¹⁴ Hence, in possessing a body part equivalent to blood, plants (and other bloodless animals) too could be capable of the intake and expulsion of air just as the blooded animals were. The reference to blood as a phenomenon affecting all beings is, rather, part of Empedocles' inclination to collapse analogies into identities¹⁵ and, so to

¹² DK 31 B 82/ Arist. *Mete.* iv 387b4-6 (Hairs, leaves, the dense feathers of birds, are the same, And the scales on sturdy limbs (ταῦτ' ἀνὰ τρίχας καὶ φύλλα καὶ οἰωνῶν πτερὰ πυκνὰ καὶ λεπίδες γίνονται ἐπὶ στιβαροῖσι μέλεσσιν).

¹³ οὕτω δ' ὥτοκεῖ μακρὰ δένδρεα πρῶτον ἐλαίας.

¹⁴ Empedocles' use of analogies has been pursued with different emphases, from epistemological to philosophical. For instance, for Lloyd it holds heuristic value and clarifies both obscure vital functions (1966, 325-333) and other unknown phenomena (334-6) and for Kamtekar it represents "a distinctive kind of thinking" (2009); Wilford takes the analogies between Empedocles' embryology and cosmology as revealing the influence of medical knowledge in conceiving the origin of the world (1968), while for Zatta (2018, and n. 23, 24 below, 2019, chap. 4) analogies express a philosophical view that sees natural world and forms of life as interconnected.

¹⁵ This claim may need some clarification. The identification of analogies both between living beings' bodies and their parts (see B 82 or B 79, quoted above), on the one hand, and physical processes and artifacts, on the other (in B 100, also quoted above, the phenomenon of respiration is compared to what happens in a water-clock), appears a standard procedure of Empedocles' inquiry. Yet Empedocles tends to unify the terms of analogies and constructs metaphors giving expression to a fundamental unity

speak, both intensify and extend the meanings of words, and hence of functions and processes. For, similarly to the above fr. 79, in which “eggs” is considered equal to and encompassing seeds, so in fr. 100 blood may stand for itself and its analogues,¹⁶ hence presenting a mechanism of respiration that affects all living beings, plants included.¹⁷ Admittedly, very little extant evidence addresses this component for plants in Empedocles and other Presocratics but a lexical commentary in Theophrastus’ *Inquiry into Plants* points to a plurality of terms. Some along with Menestor, discussed in the next section, called the moisture (τὸ ὑγρὸν) in all trees ὁπός (juice), others, by contrast, made a distinction likely according to its different density. In some trees the moisture was called δάκρυον (“tear”), in others ὁπός (juice), and still in others it was referred to it without a specific name (ἀνωνίμως).¹⁸ Empedocles must have used a general name for the moisture of all trees. Ὑγρὸν appears indeed in a testimony of Aëtius about plants’ deciduousness, quoted below (DK 31 A 70/Aët. 5.26.4). Further, in another chapter dedicated to the phenomenon of respiration, Aëtius makes clear that Empedocles discussed “the liquid” (ἡ ὑγρασία) in the context of the respiration of the first living being (πρῶτον ζῶον)¹⁹—and plants, we have seen earlier, were considered the first living beings (πρῶτα ζῶα), those that emerged from the earth before the sun started its rotation and night and day came into being. What worked for the first

among living beings and their processes. Such tendency is ultimately inscribed in his physical doctrine according to which all kinds of living beings, and in fact, everything in this world, derive from the aggregation of the divine roots (i.e., fire, earth, water, and air); see Bremen, 1980, 363-4 and n. above.

¹⁶ In fact, for Empedocles the earth too might breathe since it both exudes under the heat of the sun and has in itself an internal source of heat, hence fulfilling the conditions for respiration embodied in the model discussed in the upcoming pages (on the subterranean fire, see DK 31 A 52; on the sweat of the earth, DK 31 B 55 and Zatta 2018, esp. 59, n19, 67-9).

¹⁷ For the inclusion of plants in πάντα, see Wright 1981, 245; Ambrosano 2012, 27; Piergiacomini 2018; Bollack 1969, 478 where he notes that in this fragment Empedocles offers a model for all types of respiration, which includes the “respiration cosmique” (474).

¹⁸ See DK 32 A 2/Thph. *HP* i.2.3 (Τὸ μὲν οὖν ὑγρὸν φανερόν· ὃ δὲ καλοῦσιν τινες ἀπλῶς ἐν ἅπασιν ὁπόν, ὥσπερ καὶ Μενέστωρ, οἱ δ’ ἐν μὲν τοῖς ἄλλοις ἀνωνίμως ἐν δὲ τισιν ὁπὸν καὶ ἐν ἄλλοις δάκρυον); Cf. i.2.3; see below pp. 19.

¹⁹ As Mansfeld and Runia remark (without however pursuing the relevance of this passage for Empedocles’ conception of plants), the πρῶτον ζῶον in question was born from the earth (2020, 1727).

creature must also be working for actual plants, inasmuch as they are the primitive beings that survived into the present time.²⁰ Aëtius writes,

Ἐμπεδοκλῆς τὴν πρώτην ἀναπνοὴν τοῦ πρώτου ζώου γενέσθαι τῆς <μὲν> ἐν τοῖς βρέφεσιν ὑγρασίας ἀποχώρησιν λαμβανούσης, πρὸς δὲ τὸ παρακενωθὲν ἐπεισόδου τοῦ ἐκτὸς ἀερώδους γινομένης εἰς τὰ παραχνοιθέντα τῶν ἀγγείων· τὸ δὲ μετὰ τοῦτο ἤδη τοῦ ἐμφύτου θερμοῦ τῇ τὸ ἐκτὸς ὁρμῇ τὸ ἀερώδες ὑπαναθλίβοντος, τὴν ἐκπνοὴν, τῇ δ' εἰς τὸ ἐντὸς ἀνθυποχωρήσει τῷ ἀερώδει τὴν ἀντεπίσσοδον παρεχομένου, τὴν εἰσπνοὴν [...].

The first inhalation of the first living being came about when the liquid in the *brephesin*²¹ withdrew and the external airy element entered from the outside via the opening of the vessels into the empty spaces that resulted. Afterwards, exhalation [scil. came about] when the innate heat expelled the airy element by its impulse outward, inhalation when it provided the airy element with a reverse passage inward by withdrawing in the opposite direction [...]. (DK 31 A 74/Aët. 4 22 1)

Compatible with the mechanism presented in fr. 100, here too it is because the liquid internal to the body (ὑγρασία) (and corresponding to the blood in fr. 100) withdraws from the vessels that the external air is able to penetrate and is successively expelled. But there is another factor as well. For now we are also told that what propels the air out is the internal heat of the first living being, and integrating this testimony into the mechanism described in fr. 100, we should suppose that as the internal heat pushes the air forward the body liquid advances, in a continuous rhythmical cycle that involves receding liquid and incoming air, followed by advancing liquid and outgoing air. As for the term βρέφος in Aëtius' testimony, it is a little ambiguous. In Greek language it may signify either the embryo or the new-born²² and appears in several testimonies on

²⁰ On plants as primitive creatures, see Guthrie 1965, 209. It bears noting that plants' upward constitution and permanent link to the earth resemble that of the οὐλοφνεῖς, the members of the third zoogony, which the subterranean fire pushed up from the earth (DK 31 B 62). These living beings lacked sexual differentiation and possessed an equal amount of fire and water. The intrinsic lack of air implies that (like plants) the whole-natured creatures did not possess blood either—the body part that, for Empedocles, constitutes a fusion of all four elements (DK 31 B 98). See Bignone who appeals to DK 31 A 74/Aët. iv.22.1 (cited below) to argue that, in lacking air, the “whole-natured” beings absorb it following the evaporation of the water intrinsic to their bodies (1916, see his note to fr. 62, 450-1, and 578, 581-2). In other words, the whole-natured engaged in a primitive form of respiration, and given their physiological closeness to actual plants, one can infer that these too were, according to Empedocles, breathing (as argued here).

²¹ Given the ambiguity of the term βρέφος, discussed below, I leave it transliterated.

²² With the meaning of foetus it appears already in Homer (*Il.* xxiii 266) while in later poets it means new-born babe (see for instance *Pi. O.* 33, *A. Ag.* 1096); see LS sv βρέφος.

Empedocles with the first meaning.²³ Hence it raises the question of when exactly the first living being (i.e., the plant) started breathing. In other words, did it take in air at, so to speak, the embryological stage inside the earth or once it emerged (or, perhaps better, as it started to emerge)? The mention of the outside air indicates that βρέφος is referring to the new-born. And, indeed, corroborating evidence comes from another testimony—still from Aëtius—in which the same mechanism of respiration described for the first living being (receding ὑγρασία/incoming air) is brought up in a chapter dedicated to the discussion of whether the embryo is an animal. Here we learn that for Empedocles the embryo does not breathe while inside the mother’s belly but that it starts doing so as it comes to light (κατὰ τὴν ἀποκύψιν).²⁴ It is then that the moisture²⁵ of the newborn (i.e., blood) recedes allowing the external air to come in. In starting when the first living being emerged from the earth (i.e., plant) and the new-born is delivered from the mother, respiration points to an analogy between the mother and the earth, on the one hand, and their respective “products,” on the other, and further underscores the distinctive physiology of plants as living beings who breathe with the part of their body above ground but not with that which remains underground. Not otiose, this analogy is in fact at work in Empedocles’ very conception of plants. For he did not only consider them the first living beings (πρῶτα ζῶα) but also “like embryos in the earth.” In a chapter dedicated to the question of whether plants are animals (ζῶα), Aëtius writes

αὔξεσθαι δ’ ἀπὸ τοῦ ἐν τῇ γῇ θερμοῦ διαιρομένου, ὥστε γῆς εἶναι μέρη, καθάπερ καὶ τὰ ἔμβρυα τὰ ἐν τῇ γαστρὶ τῆς μήτρας μέρη

²³ For instance, in DK 31 B 70 and DK 31 B 153a βρέφος indicates the embryo inside the mother’s belly; cf. DK 31 A 75 in which βρέφος is brought up in a discussion of the gestation of the embryo in primeval times when human beings were generated from the earth.

²⁴ See Aët. v.15.3 (Ἐμπεδοκλῆς μὴ εἶναι μὲν ζῶον τὸ ἔμβρυον ἀλλ’ ἄπνουν ὑπάρχειν ἐν τῇ γαστρὶ). On this passage as complementary to the one on the respiration of the first living being, discussed earlier (DK 31 A 74/Aët. iv. 22.1, see p. 8), see Runia, Mansfeld, 2020.

²⁵ In this passage on the embryo the use of the term *hygrasia* is noteworthy inasmuch as it refers to blood and points to the equivalence in Empedocles’ doctrine between blood and liquid.

They [plants] grow from the heat in the earth that separates, so that they are parts of the earth, just as embryos in the belly are parts of the womb.²⁶

Unlike the new-born, who have exited the bodies of their mothers and grown out of embryos, plants are like permanent embryos and maintain a visceral connection with the earth from which they derive their nourishment. The difference with actual embryos, we may insist, is that they partially emerge from the body of the “mother” and conduct a double life, with a part outside and a part inside. And it is by virtue of the continued relation with the earth that plants are generated and that they grow because generation and growth for them are due to “the heat in the earth that separates.” On this view, then, the heat, in separating the plants from the earth, becomes not only part of the plants’ bodies—the component that makes them stretch upward (while their earthy component pushes them down)(Aristot. *DA* 2 415b28-416a2)—but also, arguably, that which propels, in the part of the body above the ground, the exit of the inhaled air after it has been taken in.²⁷ In other words, plants’ blood equivalent along with their body passages and internal heat, makes it possible for them to breathe in the same way as the newborn and generally all the other animals do (whether blooded or bloodless), by drawing in air and then expelling it—although, as argued here, for them respiration involves the part of their body exposed to the air outside, and not the part underground.

²⁶ DK 31 A 70/Aët. v.26.4. Interestingly, in Hippocrates too the (human) embryo breathes, but via the newly formed mouth and nose, and it is through the process of respiration that the interior of the body becomes further articulated according to the principle of likes (*de Nat Puer.* 17).

²⁷ That plants possess an internal heat powerful enough to expel the air stands in stark contrast with Aristotle, who assigns them an internal heat so low that they need not breathe to cool off. For Aristotle, as mentioned earlier, mere exposure to the environment is enough to provide plants with suitable living conditions (*de Iuv.* 470a19-470b1); cf. Aristot. *PA* ii 650a3-27 in which plants are differentiated from animals based on their absorption of food concocted by (the heat of) the earth, while animals process it through their internal heat. For plants’ lack of a fixed degree of heat intermediate between hot and cold as what causes their inability to sense, see Murphy 2005.

This model of respiration helps to clarify Empedocles' conception of other vegetal phenomena, namely fructification and deciduousness. In *On the Causes of Plants* Theophrastus preserves fragments 77 and 78 in a longer passage stating,

Καὶ εἴ γε συνεχῶς ὁ ἀήρ ἀκολουθοίη τούτοις [sc. τοῖς δένδροις], ἴσως οὐδὲ τὰ παρὰ τῶν ποιητῶν λεγόμενα δόξειεν ἂν ἀλόγως ἔχειν οὐδ' ὥς Ἐμπεδοκλῆς ἀείφυλλα

καὶ ἐμπεδόκαρπά (B 77)

φησι θάλλειν

καρπῶν ἀφρονίησι κατ' ἡέρα πάντ' ἐνιαυτόν (B 78)

ὑποτιθέμενός τινα τοῦ ἀέρος κρᾶσιν, τὴν ἐαρινήν, κοινήν.

And if mild air were to accompany them [the trees] constantly, perhaps the utterances of the poets would not seem so unreasonable, nor would Empedocles claim that evergreen trees

And ever-fruiting

thrive

with abundant fruit all the year due to the air.

Supposing that a certain blend of air, the springtime air, is temperate.²⁸

We lack the wider context to which these fragments belonged. The text points to an extraordinary fruitfulness—to trees that bear fruit all year long, not merely in the accustomed season. Theophrastus pairs Empedocles with the poets, and among his antecedents, we indeed find Homer, who in book 7 of the *Odyssey* sings of the garden of Alcinoos and how a constant west breeze, the zephyr, makes the fruits grow and ripen:²⁹

ἔνθα δὲ δένδρεα μακρὰ πεφύκασι τηλεθόωντα,
ὄγχαι καὶ ῥοιαὶ καὶ μηλέαι ἀγλαόκαρποι
συκέαι τε γλυκεραὶ καὶ ἐλαῖαι τηλεθόωσαι.
τάων οὐ ποτε καρπὸς ἀπόλλυται οὐδ' ἀπολείπει
χείματος οὐδὲ θέρεως, ἐπετήσιος· ἄλλα δὲ πέσσει.
ὄγχην ἐπ' ὄγχην γηράσκει, μῆλον δ' ἐπὶ μῆλῳ,
αὐτὰρ ἐπὶ σταφυλῇ σταφυλῇ, σῦκον δ' ἐπὶ σύκῳ.
ἔνθα δὲ κοσμηταὶ πρασιαὶ παρὰ νεῖατον ὄρχον
παντοῖαι πεφύασιν [...]

²⁸ The central part of this quotation, except φησι θάλλειν, corresponds to DK 31 B 77.78 while beginning and end are by Theophrastus (Thph. *CP* i.13.2, in the edition by Amigues, translation by the author). Fr. 77 is, however, a scholarly reconstruction (see Bollack 1969 545-6, Wright 1981, 223). Regarding κοινός on the last line, it means “mixed”, that is, containing the extremes of summer and winter (Bollack, 1969, 515 n.1).

²⁹ Cf. Bollack 1969, 517. But we may consider Hesiod's golden age too (Hes. *OpD* 109-120), although in this passage, in line with the didactic nature of poem, the stress lies more on the spontaneous production of the earth which does not need human labor; there is also no mention of the wind.

Therein grow trees, tall and luxuriant,
 pears and pomegranates and apple-trees with their bright fruit,
 and sweet figs, and luxuriant olives.
 Of these the fruit perishes not nor fails
 in winter or summer, but lasts throughout the year; and even does the west wind,
 as it blows, quicken to life some fruits,
 and ripens others; pear upon pear waxes ripe, apple upon apple,
 cluster upon cluster, and fig upon fig.
 There, too, is his fruitful (*polykarpa*) vineyard planted [...]. (*Od.* 7 114-28, transl. by A. T. Murray)

The yearlong fructification of Alcinoos' trees is expressed in Empedocles with the likely newly coined adjective ἐμπεδόκαρπα.³⁰ But if we take into account the phenomenon of vegetal respiration, Empedocles' line points to a physiological meaning that is absent in Homer and Theophrastus, and neglected in the commentaries on Empedocles. Bollack, for instance, interprets B 78 above in terms of the adaptation of the mixture of the tree to that of the air, and of an unqualified "exchange" between the two, without referring to respiration.³¹ Similarly, Wright speaks of a harmony between the *krasis* of tree and that of air/climate.³² But in B 78 it is not only through mere contact and, so to speak, a still harmony that air causes the fruit to grow and ripen. Empedocles' mention of the spring-like mixture of the air (*krasis aeros*) alludes to that season's optimal moisture and warmth implying plants' *interaction with it* (i.e., respiration): when plants inhale this warm, moist air, it contributes to the constant formation of fruit. And, indeed, Aëtius reports that for Empedocles fruits consisted in an excess of water and fire,³³ which was arguably produced in plants' bodies through the synergy of respiration via the pores and nutrition from the roots.³⁴ On the other

³⁰ See DK 31 B 77.78/ Thph. *CP* i.13.2, quoted above. As Wright notes, ἐμπεδόκαρπα is a unique compound adjective (i.e., a hapax), probably a pun on Empedocles' own name (1981, 224).

³¹ 1969, 505, 514-7.

³² 1981, 214.

³³ DK 31 A 70/Aët. v.26.4 (τοὺς δὲ καρποὺς περιττεύματα εἶναι τοῦ ἐν τοῖς φυτοῖς ὕδατος καὶ πυρός). Bollack considers the water and fire as surplus tied to the plants' development (1969, 504), Repici as residues internal to the plants themselves (2000, 71), but I take them to derive from their air inhalation a certain mixture beyond nutrition.

³⁴ Bollack interprets B 78 also in light of Aëtius' testimony about trees' evergreenness and deciduousness (quoted below) and, in addition to the adaptation of the mixture of the air to that of the tree, points out

hand, in the normal course of seasons with varying types of air, the optimal mixture (of air) would characterize spring only, circumscribing fruit production to this period of the year. Thus, if this interpretation of Empedocles' thought is correct, vegetal respiration constituted a phenomenon concomitant to nutrition, not separate from it, as Aristotle's anatomical view will later hold.³⁵ After all, such an interlacing of respiration and nutrition (admittedly, with reference to human bodies) emerges from Plato's *Timaeus* itself,³⁶ which responds to and often incorporates Presocratic doctrines and also from Diogenes of Apollonia who argues that the intake of warm air speeds up the digestive process of birds (Thph. *de Sens.* 44/DK 64 A 19).

As for the phenomenon of deciduousness, this too can be interpreted in terms of Empedocles' conception of vegetal respiration. In the same passage in which Aëtius refers to the constitution of fruits as deriving from an excess of fire and water, he also reports that for Empedocles,

καὶ τὰ μὲν ἐλλιπὲς ἔχοντα τὸ ὑγρόν, ἐξικμαζομένου αὐτοῦ τῷ θέρει, φυλλορροεῖν, τὰ δὲ πλεῖον παραμένειν, ὥσπερ ἐπὶ τῆς δάφνης καὶ τῆς ἐλαίας καὶ τοῦ φοίνικος.

those [trees] that lack moisture (*to hygron*) due to its evaporation (*exikmazomenou*) during the summer lose their leaves, but most of them keep them, as in the case of the laurel, olive, and palm.³⁷

In this testimony ἐξικμάζειν is a key term: it indicates the evaporation of humidity through the trees' body pores. Aristotle uses this verb to indicate the effect of the heat that draws moisture from the earthy substance causing it to become the egg's shell (*GA*

that also the tree's "happy constitution and circulatory system" contribute to an abundant fructification and evergreeness" (516).

³⁵ See, for instance, Aristotle's critical discussion of *Timaeus* at *Resp.* 472b7-473a14, esp. 473a3-14.

³⁶ See Plat. *Tim.* 78e-79, and Cornford, 1997, 306-7 (for, respectively, the connection of respiration to nutrition, and the influence of Empedocles' theory of respiration on Philistion and then Plato) and 314-5.

³⁷ DK 31 A 70/Aët. v.26.4. Interestingly, as Manfeld and Runia remark, the verbs adopted to indicate, respectively, the falling of the leaves and their permanence on the trees (φυλλορροεῖν and παραμένειν) appear also in Plutarch's testimony about Empedocles' doctrine about these vegetal phenomena (*Quest. Conv.* 649D; see Manfeld, Runia 2020, 2016). These authors remark that the two accounts differ, but I believe they can still be reconciled if we take into consideration Empedocles' systemic view of plants and the way their upper and lower parts contribute to nutrition. That is, 1) the evaporation unbalancing plants' mixture and causing the leaves to fall, appealed to in Aëtius, is to be attributed to the extensive porosity of plants' bodies, advocated for (albeit, with respect to nutrition) in Plutarch, quoted below, and 2) the food introduced from the roots is unable to reach the upper extremity of the tree (see below).

1 718b19). In Theophrastus it applies to the chickpea, from which the brine (ἄλμη) extracts the excess fluid making it superior (Thph. *CP* 4 8 4). In Empedocles, on the other hand, the loss of humidity due to the summer heat causes some trees to drop their leaves: the heat makes the tree evaporate, and the successive intake of dry air does not compensate for this loss,³⁸ nor does the nourishment received through the roots.³⁹ For, as we learn from another testimony, Empedocles disagreed that trees are evergreen on account of their internal heat and deciduous on account of internal cold.⁴⁰ Rather, evergreen trees are able to maintain their leaves because “an adaptation of their internal passages” allows a regular flow of food to the leaves. By contrast, deciduous trees possess tight channels in the lower part of their body and loose ones in the upper, and are thus unable to secure such steady and capillary nourishment. The food tends to remain in the large channels and nourish the surrounding areas without being diffused to the plants’ extremities.⁴¹

³⁸ In the absence of evidence, one might question, I believe, whether the loss of humidity is concomitant with the process of respiration or involves other pores. Given that respiration implies an oscillation between inside moisture and outside air, the same passages may well be responsible for the evaporation of the liquid and its exit. For, when the tree’s moisture reaches the surface of the body it is more exposed to the external heat and hence evaporates exiting, so rarefied, through the pores which are, normally, small enough to allow the entrance of air but too small to let the liquid go out.

³⁹ Bollack remarks that trees are then able to produce leaves again because winter brings them the humidity they have lost during the summer. In this way, “the balance is restored by an opposite exchange” (1969, 504). Yet, not even here, does Bollack interpret such restoration in terms of vegetal respiration.

⁴⁰ Not only does Empedocles’ dismissal of trees’ internal temperature suggest his disagreement with Menestor (see below p. 16). It also seems to deny Bollack’s claim that Empedocles came up with a classification of plants in terms of internal heat and cold (1969, 504), a doctrinal position that should be rather attributed to Menestor and Cleidemus. After all, for Empedocles all plants were generated and growing on account of fire which separates from the earth (DK 31 A 70/Aët. v.26.4, discussed on pp. 9-10 above).

⁴¹ DK 31 *ad* B 77/LM EMP. D 248/Bollack 580/ Plut. *Quaest. conv.* 649D (τὸ δ’ αἰθαλὲς τοῦτο καὶ ὧς φησιν Ἐμπεδοκλῆς ἐμπεδόφυλλον οὐκ ἔστι θερμότητος· οὐδὲ γὰρ ψυχρότης τὸ φυλλοροεῖν . . . ἐνιοὶ μὲν οὖν ὁμαλότητι κράσεως οἶονται παραμένειν τὸ φύλλον· Ἐμπεδοκλῆς δὲ πρὸς τοῦτω καὶ πόρων τινὰ συμμετρίαν αἰτιᾶται τεταγμένως καὶ ὁμαλῶς τὴν τροφὴν διέντων ὥστ’ ἀρκοῦντως ἐπιρρεῖν. τοῖς δὲ φυλλοροοῦσιν οὐκ ἔστι διὰ μανότητα τῶν ἄνω καὶ στενότητα τῶν κάτω πόρων, ὅταν οἱ μὲν μὴ ἐπιπέμπωσιν οἱ δὲ <μὴ> φυλάττωσιν ἄλλ’ ὀλίγον λαβόντες ἄθρουν ἐκχέωσιν, ὥσπερ ἐν ἀνδῆροις τισὶν οὐχ ὁμαλοῖς· τὰ δ’ ὑδρεύμεν’ αἰεὶ τὴν τροφὴν διαρκῆ καὶ σύμμετρον ἀντέχει, καὶ παραμένει ἀγήρω καὶ χλοερά. For this property of being an evergreen and, as Empedocles says, perpetual leafiness [ἐμπεδόφυλλον] is not a characteristic of heat, nor is deciduousness a characteristic of cold . . . Some people think that leaves persist because of the regularity of the mixture. But Empedocles also attributes the cause to a certain adaptation of the passages that permit nourishment to enter in an orderly and regular manner, so that it arrives in sufficient quantity. But this is not possible for deciduous trees,

There is one more testimony that contributes to an understanding of Empedocles' notion of vegetal respiration. According to Plutarch, Empedocles believed that plants' capacity to take in water (ὕδρευομαι) empowered them to preserve their lives:

τηρεῖται δὲ τοῖς φυτοῖς ἀναισθητῶς ἐκ τοῦ περιέχοντος, ὥς φησιν Ἐμπεδοκλῆς, ὕδρευομένοις τὸ πρόσφορον· ἡμᾶς δ' ἡ ὄρεξις ζητεῖν διδάσκει καὶ διώκειν τὸ ἐκλείπον τῆς κράσεως.

Regarding plants, their lives are preserved without awareness thanks to what surrounds them as Empedocles says when they draw in for themselves the water they need; but in our case, the appetite teaches us to look for and pursue what is lacking in our mixture. (DK 31 A 70/Bollack 576/ Plut. *Quaest. Conv.* 688A)

Empedocles' belief that plants' acquisition of water (and consequent life preservation) happened not only through the roots but also through the pores of the body via respiration, is indicated by the word περιέχον, which means “what surrounds” and refers to the air plants inhale in its different mixtures according to the seasons. The verb περιέχειν was already used in a cosmic context by Anaximenes discussing the πνεῦμα and air that encompass the world (DK 13 B 2/Aët. 1 3 4), Aristotle applied it to plants to explain how they cooled off by the mere contact with the surrounding (τὸ περιέχον, i.e. air; Aristot. *de Iuv.* 470a19-23), while, in a similar but more specialized context, Theophrastus later adopted it in his discussion of the date-palm tree, which likes the heat in the surrounding air causing the ripening of its fruit.⁴² Unlike Aristotle and then Theophrastus, however, for Empedocles plants entertained a more active relation with their environment because they were able to take in moisture together with the air on account of their body porousness, a process discussed earlier in relation to their abundant fructification. So, it seems, Empedocles held a systematic view of

because the upper passages are loose and the lower ones are tight, when the latter do not send it up and the former <do not> keep it, but having received only a little they release it in abundance, as happened with some flowerbeds that present irregularities. But plants that are always well watered with a sufficient and adapted nourishment persist, so that they endure without getting old and remain green).

⁴² Thph. *CP* iii.17.4 (Ὁ δὲ φοῖνιξ τὸν μὲν ἀέρα τὸν περιέχοντα ζητεῖ θερμόν--οὔτω γὰρ ἡ πέπανσις τοῦ καρποῦ). Needless to say, for Theophrastus, again, it is matter of mere contact rather than inhalation.

plants' bodies. The part exposed to the air and driven up by the fire constituent contributed to the preservation of the plant and its fructification and worked in synergy with the embryological part tied to the earth and pushed down by the like constituent. For the seasonal moisture drawn in from the surrounding air supplemented the constant nourishment from underground. When the moisture from the surrounding was lacking in summer and the tree possessed asymmetrical pores, then it lost its leaves, but if the pores were symmetrical and allowed, so to speak, a capillary form of nutrition to the upper part of the tree then the foliage remained evergreen.

2. Menestor of Sybaris: Vegetal Heat and Respiration

Menestor of Sybaris, a contemporary of Empedocles, also believed that plants could breathe. An obscure Presocratic whose thought has been transmitted only by Theophrastus and glossed over in secondary literature,⁴³ Menestor is the earliest Greek botanist and dealt with different phenomena of vegetal life.⁴⁴ Like Empedocles he also inquired into trees' evergreenness but attributed it to their internal heat⁴⁵ rather than to an ideal porous constitution and the steady inflow of food reaching the leaves through regular passage.⁴⁶ While hot plants preserved their foliage, for Menestor cold ones lost it. He appealed to plants' temperature also to explain their growth, budding, and

⁴³ Menestor is absent from Guthrie's history of Greek philosophy (1965) while, in their study of ancient botany, Hardy and Totelin (2016) only mention Menestor, after Anaxagoras and Empedocles, within a list of other Presocratics who dealt with plants (2016, 182). Repici discusses the evidence regarding Menestor's beliefs on plants and their compatibility with their environment (2000, 93-4) but not in terms of vegetal respiration as pursued in this essay.

⁴⁴ See Zhmud 2008, 547. Yet if all the testimonies have to do with plants, DK 32 A 5 indicates that Menestor discussed also animals and likely in terms of continuity with plants as Empedocles. That is, without categorical differentiation between the two as in Diogenes and later Aristotle. For, we learn, Menestor followed Empedocles' "doctrine of opposites" (i.e., fiery fish living in cold environments) *not only with respect to animals* but extended it to plants.

⁴⁵ Thph. CP i.21.7/DK 32 A 5). Cf. Capelle 1961; Zhmud 2008, 547-8.

⁴⁶ In this respect, then, Plutarch's testimony, quoted above in n. 55, achieves a new depth. In affirming that Empedocles discarded internal heat as the factor determining plants' evergreenness, it suggests a direct critique of Menestor and perhaps his slight earlier date, as Zhmud has hypothesized. It also seems then that, with respect to plants' evergreenness, Menestor held a simpler view than Empedocles.

fructification, in this case too showing interests similar to Empedocles'.⁴⁷ For instance hot plants grew faster and budded earlier than cold ones, and produced fruit.⁴⁸ But plants' temperature was also key to comprehending their capacity to live in specific habitats and a factor tied to their respiration. In *On the Causes of Plants* Theophrastus writes,

Ἑτέρα δ' ἡ κατὰ τὰς χώρας θερμάς καὶ ψυχράς· τὰ γὰρ ἐναντία ἐν ταῖς ἐναντίαις δύνασθαι διαμένειν, τὰ μὲν θερμὰ ἐν ταῖς ψυχραῖς, τὰ δὲ ψυχρὰ ἐν θερμαῖς. Οὕτω γὰρ εὐθὺς καὶ τὴν φύσιν γεννᾶν, ὥς ὑπὸ μὲν τοῦ ὁμοίου φθειρομένων διὰ τὴν ὑπερβολήν, ὑπὸ δὲ τοῦ ἐναντίου σφζομένων οἷον εὐκρασίας τινὸς γινομένης, ὥσπερ καὶ Ἐμπεδοκλῆς λέγει περὶ τῶν ζώων· τὰ γὰρ ὑπέρπυρα τὴν φύσιν ἄγειν εἰς τὸ ὑγρόν. Συνηκολούθηκεν δὲ ταύτῃ τῇ δόξῃ καὶ Μενέστωρ οὐ μόνον ἐπὶ τῶν ζώων, ἀλλὰ καὶ ἐπὶ τῶν φυτῶν· θερμώτατα γὰρ εἶναι φησιν τὰ μάλιστα ἔνυγρᾶ, οἷον σχοῖνον κάλαμον κύμειρον, δι' ὃ καὶ ὑπὸ τῶν χειμῶνων οὐκ ἐκπύγνυσθαι, καὶ τῶν ἄλλων ὅσα μάλιστα ἐν τοῖς ψυχροῖς δύνασθαι διαμένειν, οἷον ἐλάτην πεύκην κέδρον ἄρκευθον κιττόν, ἐπὶ τούτου γὰρ οὐδὲ τὴν χιόνα τῇ θερμότητι ἐπιμένειν· ἔτι δὲ σκολιὸν εἶναι διὰ τὴν ἐντεριώνην, θερμὴν οὖσαν, καὶ διαστρέφειν.

A second cause is shown by the character of the country (κατὰ τὰς χώρας) (as when it is cold); for plants (it is urged) are able to survive in the countries of a character opposite to their own, one set surviving in hot countries, the other in cold ones. For this (it is argued) is how their nature generated them at the outset, since they are killed by the like character in their habitat, owing to the resultant excess, but are preserved by the character opposite to their own, since the result is a kind of tempering (*eukrasia*). So Empedocles says of animals that the ones with an excess of fire are brought by their nature to water. Menestor too follows this view not only for animals but for plants as well, saying that the hottest plants are those that live most in water, as rush, reed and galingale (which is why they do not freeze out in winter), the hottest of the rest being able to survive in cold localities as silver fir, pine, prickly cedar, Phoenician cedar and ivy (the last being so hot that snow does not even remain on it, and again it is crooked because, he says, its pith is hot and warps it). (DK 32.5/Thph. *CP* 1 21 5-6)⁴⁹

For Menestor, plants can live in environments that complement their body temperatures: hot plants live in cold areas, cold plants in hot ones.⁵⁰ He adopted this principle from Empedocles, who believed that fish originated first on land and because they were very hot, sought and found a suitable environment in water, which cooled

⁴⁷ See DK 32 A 5/Thph. *CP* i.21.5. Further, Menestor shared with Empedocles also an interest in the qualities and causes of plants' juices and the effect of soil on plants (cf. Thph. *CP* ii.4.3/DK 32 A 6, Thph. *CP* vi.3.5/DK 32 A 7 and DK 31 A 70).

⁴⁸ See, respectively, Thph. *CP* vi.3.7/DK 32 A 5, *CP* ii.4.3/DK 32 A 6, and Thph. *CP* i.21.5-6/DK 32 A 5. Cf. Capelle 1961; Zhmud 2008, 547-8.

⁴⁹ For Theophrastus' appraisal of this tenet, see Viano 1992. Regarding the thermic compatibility between plants and their environment, Repici remarks that if hot plants were to live in hot areas and cold plants in cold ones they would be destroyed by the excess of similar properties (2001, 93).

⁵⁰ Also Cleidemus, another obscure Presocratic, distinguished between hot and cold plants contemplating a range of temperatures in between. For he stated that plants were composed of the same things as animals but that they were further removed "the murkier and the colder" they were (DK 62.3/Thph. *HP* iii.1.4: Κλειδημος δὲ συνεστάναι μὲν ἐκ τῶν αὐτῶν τοῖς ζώοις, ὅσῳ δὲ θολερωτέρων καὶ ψυχροτέρων, τοσοῦτον ἀπέχειν τοῦ ζῆα εἶναι.)

them off through the process of respiration.⁵¹ The optimal relation between plants and their environments, Menestor theorized, led to “a kind of tempering” or, in other words, a good mixture (εὐκρασία τις), which we should likely consider, as earlier in the case of Empedocles, as dynamic and not merely involving a bare contact of the plant with its surroundings. For in transferring Empedocles’ principle from fish to plants, Menestor must also have thought that plants breathed through the pores in their bodies—just as the fiery fish and, as I have argued here, all other living beings did for Empedocles. Each plant could live in an area suitable to its body temperature, as its life was maintained through a regular exchange with its surroundings: hot plants introduced cold air, cold plants “hot” air. In this way, it was possible for them to avoid excessive heat and excessive cold, which would have destroyed them.⁵² And, even though we lack evidence in this respect, the introduction of hot air in cold plants and vice versa was likely contributing to their vital processes as these were related to the internal temperature. Hence, Menestor regarded the relationship of plants to the environment as key to understanding their life. Further, it is also noteworthy that in the above testimony Menestor does not merely distinguish between hot and cold plants, with relative (cold and hot) environments and processes of respiration. For in distinguishing between the hottest plants in absolute (i.e., those that live in water) and

⁵¹ On the hot nature of aquatic creatures, see Aristot. *PA* ii 648a25 (DK 31 A 73) and especially *On Respiration* (477a32) where Aristotle criticizes Empedocles’ belief from a teleological point of view but also implies that fish for Empedocles were breathing creatures. So they were later for both Anaxagoras and Diogenes (*Resp.* 470b31-471a6) inasmuch as they breathed in the air contained in water. It bears noting that Empedocles’ belief on fish migration contrasts with a testimony by Aëtius according to which animals that found a suitable environment in water contained much water in themselves (DK 31 A 72/Aët. v.19.5). Guthrie resolves this contradiction by attributing fishes’ migration to an aquatic environment to an earlier zoogony dominated by Love when opposites attract. By contrast, the fishes that, according to Aëtius, found in water a more familiar environment belongs to a zoogony that developed under the influence of Strife, when similars attract (1965, 206). On Empedocles’ fiery fish and their respiration, see Longrigg 1965.

⁵² Arguably, if, as Menestor believed, hot plants living in cold environments bud earlier, hot plants living in hot environments would be unable to bud, let alone to live. Likewise, if cold plants in hot environments bud later (than hot plants), in cold environment their budding would not be merely retarded but suppressed on account of the excessive cold.

the hottest plants on land Menestor shows he considers respiration from a comparative view and comes up with a scale of internal heat. In other words, he conceives respiration as a qualitative process that varied according to plants' different constitution and ensuing relation with their habitats. If the hottest plants find a suitable environment in water (i.e., rush, reed and galingale), the hottest among the land plants are able to survive in cold areas (i.e., the silver fir, pine, prickly cedar, Phoenician cedar and ivy).⁵³ The hottest of these all is in fact the ivy, whose branches are warped on account of its internal heat and which alone is hot enough to melt the snow that falls on it. In fact, that Menestor believed in a scale of vegetal temperature can also be inferred from further scrutiny of the evidence about plants' fructification. For in the series of proofs he adduces for assessing the existence of hot and cold plants he claims that the first ones produce fruit while the second are fruitless (ἄκαρπα),⁵⁴ but he also claims, as we have seen earlier, that hot plants bud and produce fruit earlier (i.e., than cold plants).⁵⁵ In this case, though, the reference is not to absolutely cold plants (for cold plants do not produce fruit), but to colder plants with respect to those that are hotter and bud and produce fruit earlier.

Theophrastus' *Inquiry on Plants* offers us two pieces of corroborating evidence for Menestor's belief in plants' respiration. On the one hand, we learn that he called plants' sap "juice" (ὀπός), a fact that shows that he discussed plants' internal components and identified the liquid analogue to blood involved in the process of epithelial respiration.⁵⁶ On the other hand, Menestor explicitly claimed that the ivy

⁵³ If Theophrastus' testimony is accurate, that these plants are able to survive (δύνασθαι διαμένειν) in cold environments suggests that Menestor has traveled to elevated areas in Southern Italy (or elsewhere) where the temperature is lower with respect to the coastal Sybaris.

⁵⁴ DK 32 A 5/Thph. *CP* i.21.5 (μία μὲν οὖν αἰτία λέγεται τῶν θερμῶν καὶ ψυχρῶν ἢ εἰς τὸ κάρπιμον ἀνάγουσα καὶ ἄκαρπον, ὥς τῶν μὲν θερμῶν καρπύμων ὄντων).

⁵⁵ DK 32 A 5/Thph. *CP* i.21.7 (τρίτην δ' αἰτίαν λέγει τοῦ προινλαστῆ καὶ προίκαρπα εἶναι· φύσει γὰρ καὶ ὁ ὀπὸς αὐτοῖς ὢν θερμὸς καὶ βλαστάνειν πρῶι ποιεῖ καὶ πέττειν τοὺς καρπούς).

⁵⁶ Thph. *HP* i.2.3/DK 32 A 2. Regarding the term ὀπός, Amigues remarks that it generally means sap but also juice and the milk of plants as in the figtree and the poppy, cf. *HP* i.12.2 (1988, vol. 1, 73).

breathes: “Fire-sticks are made from many kinds of wood, but best, according to Menestor, from ivy: for it breathes very quickly and very much.”⁵⁷ In this testimony Menestor takes a shortcut and explains the efficacy of the fire-sticks derived from the ivy by referring to the plant’s intense respiration. The ivy breathes “very quickly and very much”—bringing in cool air to temper its internal heat—because it is the hottest plant and its hot nature determines the high flammability of its fire-sticks. Accordingly, then, the ivy’s peculiar ability to melt snow involved not simply contact with its hot body but also its process of respiration and, more specifically, the intake of cold air and the exhalation of warm air. For, if I have interpreted the process of respiration correctly, the air, introduced into the ivy’s hot body, becomes warmer and is successively expelled by the plant’s heat causing the snow to melt. These testimonies about ivy’s superlative hot nature and corresponding breathing are not only relevant to Menestor’s conception of the ivy: they have a broader importance because they indicate that for Menestor, plants’ respiration was a modulated phenomenon that varied according to the heat specific to each plant. The hottest plants needed to breathe more intensively than moderately hot (or cold) ones, which breathed less. In this way, Menestor’s position on vegetal respiration was close to that of Aristotle with regard to

⁵⁷ DK 32 A 3/ Thph. *HP* v.9.6 (Πυρεῖα δὲ γίνεται μὲν ἐκ πολλῶν, ἄριστα δέ, ὥς φησι Μενέστωρ, ἐκ κίττου· τάχιστα γὰρ καὶ πλεῖστον ἀναπνεῖ). This sentence has usually been interpreted as referring to the high inflammability of the ivy (see Hort, “for that [i.e., the ivy] flares up most quickly and freely”; Amigues, “c’est le bois qui jette le plus vite la flamme plus copieuse”; Reale “perché si accende subito con gran fiamma”) and there is certainly good reason to translate it as such because it suits Theophrastus’ context (i.e., the discussion of the impact of fire on different qualities of wood and the use of wood in human activities) and interpretation. But, given Empedocles’ influence on Menestor, the verb ἀναπνεῖν in DK 32 A 2 strikingly echoes Empedocles’ B 100 (see line 1, “ὧδε δ’ ἀναπνεῖ πάντα καὶ ἐκπνεῖ· πᾶσι λίφαιμοι”) and has to be interpreted in terms of living beings’ respiration; cf. Longrigg who speaks of the “panting ivy” (1965). It may be worth remarking here too that at the end of Menestor’s list of proofs in support of the hot and cold nature of plants (*CP* i.21.7/DK 32 A 5) Theophrastus reports one additional argument. For Menestor aquatic plants provide the best wood to lit up a fire (for the reconstruction of this part, see Amigues 2012, 160) because they are the closest to fire (*ta engista tou pyros*) and hence catch fire very quickly (τάχιστα ἐκπυρόμενα). The verb used in this passage is *ekpyreisthai*, and not ἀναπνεῖν as for the ivy. So how should we take Theophrastus’ contextualization of Menestor’s ἀναπνεῖν in DK32 A 3 I suggest that Theophrastus spoils this verb of its original meaning. For, in the wave of Empedocles, Menestor likely used it to indicate the ivy’s breathing *and* to explain its high flammability (hot plants breathe intensively and catch fire quickly) while Theophrastus ignores vegetal respiration to consider merely vegetal ignition.

animals'. For the Stagyrte too would later differentiate between the respiration of the hottest animals (i.e., those provided with blooded lungs) and the cooler animals (i.e., those with spongy or bloodless lungs); the former needed to breathe more often than the latter (Aristot. *Resp.* 470b13-27).

3. Democritus: Life, Plants and the Atomic Soul

The last Presocratic for whom it can be argued that plants were endowed with respiration is Democritus of Abdera. In a long passage in *On Respiration* Aristotle rehearses the main points of Democritus' doctrine:

Δημόκριτος δ' ὅτι μὲν ἐκ τῆς ἀναπνοῆς συμβαίνει τι τοῖς ἀναπνέουσι λέγει, φάσκων κωλύειν ἐκθλίβεσθαι τὴν ψυχὴν· οὐ μέντοι ὡς τούτου γ' ἔνεκα ποιήσασαν τοῦτο τὴν φύσιν οὐθὲν εἴρηκεν· ὅλως γὰρ ὥσπερ καὶ οἱ ἄλλοι φυσικοί, καὶ οὗτος οὐθὲν ἄπτεται τῆς τοιαύτης αἰτίας. λέγει δ' ὡς ἡ ψυχὴ καὶ τὸ θερμὸν ταῦτόν τὰ πρῶτα σχήματα τῶν σφαιροειδῶν. συγκρινομένων οὖν αὐτῶν ὑπὸ τοῦ περιέχοντος ἐκθλίβοντος, βοήθειαν γίνεσθαι τὴν ἀναπνοὴν φησιν. ἐν γὰρ τῷ ἀέρι πολὺν ἀριθμὸν εἶναι τῶν τοιούτων ἃ καλεῖ ἐκεῖνος νοῦν καὶ ψυχὴν· ἀναπνέοντος οὖν καὶ εἰσιόντος τοῦ ἀέρος συνεισιόντα ταῦτα, καὶ ἀνείργοντα τὴν θλίψιν, κωλύειν τὴν ἐνοῦσαν ἐν τοῖς ζώοις διέναι ψυχὴν. καὶ διὰ τοῦτο ἐν τῷ ἀναπνεῖν καὶ ἐκπνεῖν εἶναι τὸ ζῆν καὶ τὸ ἀποθνήσκειν· ὅταν γὰρ κρατῇ τὸ περιέχον συνθλίβον, καὶ μηκέτι θύραθεν εἰσιὼν δύνηται ἀνείργειν, μὴ δυναμένου ἀναπνεῖν, τότε συμβαίνει τὸν θάνατον τοῖς ζώοις· εἶναι γὰρ τὸν θάνατον τὴν τῶν τοιούτων σχημάτων ἐκ τοῦ σώματος ἔξοδον ἐκ τῆς τοῦ περιέχοντος ἐκθλίψεως. τὴν δ' αἰτίαν διὰ τί ποτε πᾶσι μὲν ἀναγκαῖον ἀποθανεῖν, οὐ μέντοι ὅτε ἔτυχεν ἀλλὰ κατὰ φύσιν μὲν γήρα, βία δὲ παρὰ φύσιν, οὐθὲν δεδήλωκεν. [. . .]. οὐ γὰρ δὴ ὁ θύραθεν νοῦς τηρεῖ τὴν βοήθειαν, ἀλλ' ἔσωθεν ἡ ἀρχὴ τῆς ἀναπνοῆς γίνεται καὶ τῆς κινήσεως, οὐχ ὡς βιαζομένου τοῦ περιέχοντος.

Democritus states that among animals that breathe there is a result of their breathing, and alleges that it prevents the soul from being crushed out; but he nowhere says that this is why nature has invented breathing; for generally speaking, like other natural philosophers, he never reckons upon any reason of this kind. But he does identify the soul with the heat, regarding both as first forms of spherical particles. So he contends that when these particles are being crushed by the surrounding air, which is pressing them out, breathing intervenes to help them. For in the air are a large number of these particles, which he calls mind and soul; so that when breathing takes place and the air enters, these enter too and check the crushing, preventing the soul which is in the animal from passing out. For this reason upon breathing in and breathing out depend life and death; for when the surrounding air by its crushing action wins the mastery, and nothing entering from the outside can check it, as breathing is impossible, death then comes to living creatures; for he considers that death is the passing out of such forms from the body owing to the pressure of the surrounding air. But the reason why all living creatures must die at some time, though not at any particular time, but either naturally by old age or unnaturally by violence, he has nowhere explained. [. . .]. As a matter of fact, the out-of-the-door mind does not watch for the time to help, but the origin of breathing and of all movement comes from inside, and not by pressure from the surrounding air [transl. by W. S. Hett with slight modifications]. (Aristot. *Resp.* 471b30-472a25/ DK 68 A 106)

Democritus considered the soul responsible for the life and death of all living creatures, and he pegged respiration, and hence a creature's relation with the

environment, as the fundamental vital factor. Through respiration, living beings introduced spherical fiery atoms (i.e., the soul) that prevented those inside the body from being forced out through the pressure of the surrounding air. As for the soul, it did not occupy specific parts of the body (as in Plato, for instance)⁵⁸ but, in 'Taylor's words, constituted a "simple psycho-physical structure of spherical mobile atoms permeating the entire structure of the body."⁵⁹ Only beings with a sufficient amount of soul (i.e., fiery atoms) could continue to live fully; a massive departure of such atoms would bring about their death. Still, even a residue of the soul in a dead body could be responsible for minimal phenomena such as a slight capacity for perception and the growth of nails and hairs (or, arguably, in a plant, of new sprouts).⁶⁰ Be that as it may, like Empedocles (or other Presocratics who dealt with it) also Democritus considered respiration a phenomenon shared by all living beings, the nature and extensibility of which will soon be discussed with respect to plants. Let us remark here on a tenet specific to Democritus' doctrine and pointed out by Aristotle in the passage quoted above. In attributing respiration to the pressure of atoms outside the living body, Democritus considered its origin as external to the living being, and not as intrinsic to it. Note that in those doctrines like Empedocles' (or Anaxagoras and Diogenes') in which respiration is due to a vacuum inside the body, its origin is still located in the living being itself, which pumps in the air (or water and air). For Democritus instead respiration is due, so to speak, to a "violence" of the environment on the living being. For in Aristotle's sentence the middle passive βιάζεσθαι qualifies the outside atoms

⁵⁸ For the localization of the parts of the soul in different parts of the body, see for instance *Timaeus* (69C-71D).

⁵⁹ 2003, 77.

⁶⁰ See respectively DK 68 A 117/ Aët. iv.4.7 and DK 68 A 160/Luria 586/ Tert. *de An.* 51.2 (Plato [. . .] in Politia tamen cuiusdam insepulti cadaver opponit longo tempore sine ulla labe prae animae scilicet individuitate servatum. ad hoc et Democritus crementa unguium et comarum in sepulturis aliquanti temporis denotat. But in the *Republic* . . . Plato says that a certain man's corpse lay unburied for a long time without any decomposition, preserved, so he says, by the individuality of the soul. On this point Democritus mentions the growth of hair and nails for some time after burial, transl. by C.C.W. Taylor).

forcing the body. In this view, respiration is a side effect of the environment on ensouled bodies as it intervenes to “check the crashing” of the soul atoms inside the body. But further, the fact that respiration is due to the atmospheric pressure arguably makes it a diffused phenomenon, unrelated to internal anatomy—if anything, the relevant part of the body is its surface with intrinsic permeability as in Empedocles. Every natural body that possesses a soul finds itself under outside pressure and is liable to lose its soul, and engages in the rhythmic exchange with the environment that constitutes respiration. Plants should not be the exception.

No extant evidence, however, mentions explicitly that for Democritus plants had souls, let alone that they were breathing. Regarding the possession of soul, Repici has considered it as a doctrinal possibility to be soon undermined on account of plants’ immobility. For, she observes, the movement of atoms in and out of the body gives rise to respiratory movements, which cannot be attributed to motionless plants.⁶¹ But we have seen, for Democritus the fiery soul was interspersed throughout the body and respiration a diffused phenomenon, not tied to an anatomical apparatus and certainly not to visible movements. And, besides, that a minimal possession of soul would still allow a corpse to grow hairs and nails points to the fact that plants’ growth, the sprouting of new branches, buds or leaves were for the Abderite vital phenomena due to the soul. In a crucial testimony Democritus considers plants living and discusses their longevity and short life attributing trees’ life span to the interaction of nutrition and constitution.

(7) ὥς δὲ Δημόκριτος αἰτιᾶται τὰ εὐθέα τῶν σκολιῶν βραχυβιώτερα καὶ πρωϊβλαστότερα διὰ τὰς αὐτὰς ἀνάγκας εἶναι (τοῖς μὲν γὰρ ταχὺ διαπέμπεσθαι τὴν τροφήν ἀφ’ ἧς ἡ βλάστησις καὶ οἱ καρποί, τοῖς δὲ βραδέως διὰ τὸ μὴ εὖρουν εἶναι τὸ ὑπὲρ γῆς, ἀλλ’ αὐτὰς τὰς ῥίζας ἀπολαύειν· καὶ γὰρ μακρόρριζα ταῦτα εἶναι καὶ παχύρριζα), δόξειεν ἂν οὐ καλῶς λέγειν. (8) καὶ γὰρ τὰς ῥίζας ἀσθενεῖς φησιν εἶναι τῶν εὐθέων, ἐξ ὧν ἀμφοτέρων θάπτον γίνεσθαι τὴν φθοράν· ταχὺ γὰρ ἐκ τοῦ ἄνω διέναι καὶ τὸ ψῦχος καὶ τὴν ἀλέαν ἐπὶ τὰς ῥίζας διὰ τὴν εὐθυπορίαν, ἀσθενεῖς δ’ οὕσας οὐχ ὑπομένειν· ὅλως δὲ τὰ πολλὰ τῶν τοιούτων κάτωθεν ἄρχεσθαι γηράσκειν διὰ τὴν ἀσθένειαν τῶν ῥιζῶν. ἔτι δὲ τὰ ὑπὲρ γῆς διὰ τὴν

⁶¹ Repici, 2000, 97-8.

λεπτότητα καμπτόμενα ὑπὸ τῶν πνευμάτων κινεῖν τὰς ρίζας· τούτου δὲ συμβαίνοντος ἀπορρήγνυσθαι καὶ πηροῦσθαι καὶ ἀπὸ τούτων τῷ ὅλῳ δένδρῳ γίγνεσθαι τὴν φθοράν. ἃ μὲν οὖν λέγει ταῦτά ἐστιν.

(7) The way in which Democritus explains by the same necessities the cause of the fact that those [scil. trees of which the wood is] straight live less long and bud earlier than those [scil. of which the wood is] curved—namely that in the former the nourishment from which the foliage and fruits come passes through quickly, but slowly in the latter, since the part above the ground does not have an easy passage, but the roots themselves consume it (for these have roots that are long and thick)—does not seem to be correct. (8) For he says that the roots of straight trees are weak too. For both these reasons [scil. the easiness of the passage and the weakness of the roots] they are destroyed more rapidly. For both cold and heat pass rapidly from the upper part to the roots because of the straightness of the passage, and since they are weak they do not offer resistance. In general, most of these species begin to grow old from below because of the weakness of their roots. Furthermore, the parts above the ground, being bent by the winds because of their thinness, shake the roots, and when this happens these are broken off and mutilated, and starting from these destruction comes about for the whole tree. This then is what he says. (DK 68 A 162/Thph. *CP* 2.11.7-8)

Plants with longer life expectancy were those whose roots, due to the curviness of their bodies, absorbed most of the food and became stronger as opposed to straight plants in which the food circulated to the higher parts of the body and thus left the roots weak. Now since plants were alive and subjected to death (consisting, for Democritus, as we saw above, in a massive departure of soul-atoms) they too, under atmospheric pressure, must have released and breathed in the fiery atoms. And they must have done so, arguably, through the body pores, as in Empedocles.⁶² It may be worth recalling at this point that, in a parallel testimony and in tune with the conception of plants endorsed by Empedocles and Anaxagoras,⁶³ for Democritus too plants were living beings (ζῶα).

τῶν δὲ ζῶων, ὡς καὶ πρότερον εἴρηται, οὐχ ὁμοία τις ἢ κρᾶσις ἐγένετο· ἀλλ' ὅσα μὲν πλείστου τοῦ γεώδους μετέσχε, φυτά τε καὶ δένδρα γέγονε πρὸς τῇ γῇ κάτω ἐρριζωμένην τὴν κεφαλὴν ἔχοντα, τοσοῦτον τῶν ἀναιμοτέρων καὶ ἀπόδων ζῶων διαφερόντα, παρ' ὅσον ἐκεῖνα ἔξω γῆς ταύτην κινούμενα φέρουσιν [...].

The constitution of the animals was not uniform; those containing most earth became plants and trees with their heads rooted in the earth, differing from the more bloodless and footless animals only in that only in that the latter have their heads above the ground as they move [...]. (DK 68 B 5.2/Luria 556/Hermip. *De astrol.* 2.111, transl. by C.C.W. Taylor)

⁶² In light of Democritus' belief in the interspersation of the soul-atoms with those of the body (see p. 21 above), the pressure of the surrounding must have been exercised on the entire body with a consequent release of soul-atoms from its extensive surface. Significantly, Aristotle mentions neither nose nor mouth in his account of Democritus' doctrine of respiration.

⁶³ Let us remark that in calling plants ζῶα on a par with the other animals these philosophers appear to ignore any radical difference as those advocated by Diogenes of Apollonia and later Aristotle. Diogenes indeed broke the continuity between plants and animals by denying the first the capacity to breathe, while Aristotle pinpointed in the lack of sensation plants' utter alterity with respect to animals (see above). In other words, the appellation of ζῶα for plants supports their participation in the capacities of the other living beings as the testimonies related to Empedocles, Anaxagoras and Democritus reveal.

For Democritus plants were animals whose constitution had a larger component of earth. The only difference they entertained with the more bloodless and footless animals (i.e., slugs) had to do with their head, which they kept underground while their “similar” kept it above ground as they moved. This testimony is noteworthy for different reasons. First, it indicates that locomotion was not a factor the absence of which made plants categorically different from animals. Second, it shows that Democritus considered plants anatomically opposite to the other animals—that is, oriented likewise along a vertical axis, but downward rather than upward. If animals endowed with movement kept the head above ground, plants had theirs underground. But, again, this different orientation did not imply a differentiation of categories of living beings and ensuing capacities: plants themselves were ζῷα and hence not excluded from respiration. For if for Democritus breathing was a mark of life and what sustained life, then every living entity is endowed with respiration. And for plants with heads underground, breathing under atmospheric pressure involved the part of their body exposed to such pressure and was, as mentioned earlier, epithelian (as in Empedocles).

To conclude, the analysis of the extant evidence shows that Empedocles, Menestor and Democritus attributed respiration to plants. Crucial for this belief was the lack of radical distinction between animals and plants, which in Diogenes and Aristotle consisted in plants’ exclusion from vital capacities on account of their anatomic difference from animals. But for the Presocratics criticized by Aristotle and discussed in this essay (i.e., Empedocles and Democritus), plants were considered on a par with the other animals and in terms of basic body ingredients, that is, in terms of elemental composition for Empedocles, and of interlaced atoms composing the individual’s body

and soul for Democritus. Interestingly, Democritus was the first to differentiate between blooded and bloodless animals⁶⁴ but this differentiation was irrelevant to the phenomenon of respiration, which he attributed to the pressure of atmospheric air onto all living bodies. On this view, all living beings breathed. Plants did it too because they were embedded in the physicality of the world and just like the other animals they preserved their life by breathing. Likewise, in fr. 100 Empedocles stated explicitly that “πάντα ἀναπνεῖ”. Unlike Democritus, Empedocles did not inquire on the causes of respiration⁶⁵ but described its mechanism, which he pinpointed in an oscillatory exchange between the moisture/blood intrinsic to living beings’ porous bodies and the air outside. But those shortcomings Aristotle saw in his (and others’) approach, i.e., ignorance of bodies’ internal anatomy and oblivion of causes, revealed that the Presocratics under critique comprehended living beings as dynamic entities, constantly interacting with their environments, on which they depended. Not a self-enclosed phenomenon, for plants too life stemmed from, or at least, implied a constant relation to their space of existence. And regarding their vital processes, these too were considered in synergy: in the case of Empedocles’ plants, for instance, respiration was complementary to nutrition and tied to fructification and affecting their foliage.

As for the forgotten Menestor of Sybaris, “one of the ancient *physiologoi*” (DK 32 A 7/ Thph. *CP* 6, 3, 5), he dealt with an array of vegetal phenomena and connected them to plants’ internal temperature which, according to the species, could be hot or cold, and in fact, as we infer from his observation of different vegetal habitats, modulated between these two extremes. Menestor unfolded systematically the

⁶⁴ See DK 68 A 148/Aristot. *PA* iii 665a28-33. Perhaps a veiled distinction between blooded and bloodless animals existed already in Empedocles, if we consider that ὑγρασία/ὕγρον were body constituents that played the same function as blood.

⁶⁵ If we apply Aristotle’s array of causes, Democritus appears to have investigated respiration at least from the point of view of the efficient and material causes, but not of the final one. This is a serious omission for Aristotle who remarks that Democritus speaks of the effect of respiration but not of the goal of nature (*Resp.* 472a1-2) and later stresses that “nature does nothing in vain” (*Resp.* 476a12-3).

relational outlook on life, crystallized in Empedocles' fiery fish, and explained plants' different localities in terms of a physical compatibility based on the principle of opposition. He distinguished between plants that lived in water and those that lived on earth, and among the "land plants" he considered as the hottest those living in cold environments. The fact that he adopted Empedocles' doctrine on the fiery fish living in water supports the interpretation that for him too, as for Empedocles, plants breathed, and indeed the testimony on the panting ivy confirms it. Unlike Empedocles, though, and in line with his rather exclusive botanic interests, Menestor also identified the moisture intrinsic to plants and involved in their process of epithelial respiration. And rather than conceiving respiration as a general oscillation of intake and output of air for all plants he made it a modulated process whose frequency depended on the plant's internal temperature. For, we gather, the ivy breathed more intensively than the still hot silver fir or the pine because only on its evergreen leaves did the snow not endure in wintertime.

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