Lea Aurelia Schroeder*

Replenishment and Maintenance of the Human Body (*Timaeus* 77a–81e)

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Abstract: Scholarship on Plato's *Timaeus* has paid relatively little attention to *Tim*. 77a–81, a seemingly disjointed passage on topics including plants, respiration, blood circulation, and musical sounds. Despite this comparative neglect, commentators both ancient and modern have levelled a number of serious charges against Timaeus' remarks in the passage, questioning the coherence and explanatory power of what they take to be a theory of respiration. In this paper, I argue that the project of 77a–81e is not to sketch theories of respiration, circulation, and digestion (*inter alia*), but to explain how the human body is maintained in light of and despite constant environmental depletion. Further, I argue that in order to understand this account of "the replenishing system," we need to understand Timaeus' striking analogy of the fish trap or *nassa*. Commentators have generally focused directly on the workings of the bodily construction that Timaeus likens to a fish trap, but without considering how we should understand the analogy *qua* analogy. I develop a functional reading of the analogy that yields a coherent account of the replenishing system on which previous criticisms of Timaeus' remarks on respiration do not arise. Aside from lending greater unity to the passage, both internally and within its immediate context in the dialogue, this account of the replenishing system contributes to our understanding of Timaeus' reason-and-necessity explanatory framework as applied to the human body and has noteworthy implications for specific explanatory principles, in particular like-to-like motion and circular thrust.

Keywords: circulation, digestion, human physiology, metabolism, reason and necessity, respiration, Timaeus

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***Corresponding author: Lea Aurelia Schroeder**, Philosophy Department, Yale University, P.O. Box 208306, New Haven, CT, 06520, USA, E-mail: lea.schroeder@yale.edu

1 *Timaeus* 77a–81e: Problems and Questions

At *Tim*. 68e–69a, in the transition to the third part of his speech, Timaeus highlights the importance of keeping in mind the two principal causes, reason and necessity, for discerning and understanding the natural world. He then explicitly introduces the remaining part of his speech as drawing on and combining (the works of) both reason and necessity: "Now the different kinds of cause lie separated before us, like wood for carpenters; from these we must weave together the rest of the account" (69a6–8).[1] What follows in this third part of the speech (69a–92c) contains a lengthy treatment of the human body (72c–81e), followed by an account of bodily disease (81e–86a). The treatment of the human body has tended to be comparatively neglected among scholars who do not already have vested interests in ancient physiology.[2] This is especially true of 77a–81e, which seems to raise an outsized number of problems. For one, it can easily look like a rather haphazard collection of mostly physiological topics, most prominently of what we might call blood circulation, digestion, and respiration, but also including some not obviously related material on, e.g., plants (77a–c) and the concord of musical sounds (80a–b), a topic Timaeus had explicitly postponed at 67c.[3] To give just one example, Zeyl's table of contents offers the following labelled division:[4]

> 76e7–77c5: The creation of plants.
>
> 77c6–79e9: The blood vessels and digestive and respiratory systems: the "fish trap" and the circular thrust.

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1 All translations are my own. Unless otherwise noted, I read the Greek text of the *Timaeus* in Burnet's (1902) OCT.

2 The third part as a whole has been comparatively less popular than the first two, but even within this third part, most other sections have tended to fare better, perhaps especially the creation of the mortal parts of the soul and the details of its embodiment (69c–72d) as well the later discussion of psychic diseases, psychophysical well-being in humans, and its ethical import (86b–92c). The construction of the human head at 75a ff. – perhaps the default example of reason operating within material constraints – may be an exception.

3 As Cornford describes 77c–81e (i.e., without the section on plants): "The coming sections are obscure, at first reading, because Plato seems to be describing simultaneously digestion, the circulation of the blood, respiration, and transpiration (through the skin), and even the transmission of sense-impressions. Some of these processes are dealt with very cursorily, and the anatomical connections between the various organs are left extremely vague" (1937: 303).

4 Zeyl (2000: xciv). See also Brisson (2001: 69) and Cornford (1937: xiii). The most recent article about this part of the text of which I am aware is Pelavski (2014), "Physiology in Plato's *Timaeus*: Irrigation, Digestion, and Respiration"; it discusses only 77c–81e, and, as its title indicates, takes it to concern three distinct bodily processes, and does not consider the seemingly out of place topic of plants, even though it occurs immediately before the remarks about "irrigation".

79e10–80c8: Digression on other applications of the circular thrust.
80d1–81e5: The mechanisms of respiration applied to the digestive process.

Why talk about plants and the processes of circulation, respiration, and digestion *now*, and why these processes in particular? In short, even within the larger treatment of the human body and bodily disease in this part of the dialogue, 77a–81e seems conspicuous in its lack of a unifying rationale, lodged as it is between (i) Timaeus' remarks on the teleological design of body parts and tissues, which straightforwardly illustrate and explain the cooperation between reason and necessity (72c–76e), and (ii) the account of bodily diseases (82a–86a), which offers important background for the subsequent discussion of psychic disease and psychophysical well-being.[5]

Aside from the apparent lack of unity and cohesion, even the content of the allegedly disparate subsections of the passage raises significant interpretive challenges. When taken to offer a *theory of respiration*, the account has been criticized – sensibly enough – for not incorporating crucial features of respiration, such as the "cooling function" of the lungs discussed earlier in the dialogue (70b–d). Similarly, when read as an account of respiration, it has been criticized for failing to explain, and perhaps even failing to allow, indisputable and evidently relevant phenomena such as the human ability to hold one's breath.[6] Even what Timaeus *does* have to say about respiration has not been exempt from criticism, as it is not clear whether the "fish trap"-like system introduced to model certain aspects of respiration can explain (rather than assume without justification) features as basic as the change in direction in the flow of air that we experience when inhaling and exhaling.[7] Finally, as Zeyl's division of the passage above indicates, it is clear that the principle of motion in a plenum that is sometimes called *periōsis* or "circular thrust" provides some sort of relevant link between the motion involved in the fish trap-like physiological system and certain other cases of motion in a

5 The latter has more recently gained attention for its striking use of ethical and political vocabulary as well as the nature of its classification of disease. On the ethical and political dimension of the account of bodily disease, cf. Betegh (2020); Lloyd (2003). See Grams (2009) and Prince (2014) for two recent interpretations of the classification of disease, both of which treat it as an instance of the so-called "Method of Collection and Division".

6 These criticisms go back to Aristotle (esp. *De Resp*. 5–6) and Galen *(PHP* 8.8, 708/712 K ff.). I return to these charges in section 3.

7 According to Cornford (1937: 317–18), Timaeus' theory accommodates the change in direction only by tacitly assuming that air enters and leaves the body via the same route, a crucial assumption that is not explained in the text and that Cornford himself seems to consider "improbable". Pelavski (2014: 69–70) posits alveoli-like structures to account for the change in direction (without textual support, as far as I can tell). I return to this issue in section 2. Other commentators, including Joubaud (1991); Karfík (2012), do not mention the question.

plenum that are mentioned in the so-called digression from 80a–c. What exactly this link amounts to, however, is far from clear, not least because it is not clear how we should understand the motion of the relevant phenomena.

In this paper, I defend a reading of the passage from 77a–81e – plants and all – as an account of the replenishment and maintenance of the human body whose construction Timaeus has just discussed in 72c–76e. The main project of 77a–81e is not to give an account of what we (today) might call respiration, circulation, and digestion *simpliciter*, or even of the interaction of those systems *per se*. Rather, Timaeus here aims to give an account of how the human body is maintained in light of and despite the depletion it suffers, and that account involves what we think of as respiration, circulation, and digestion insofar as they are relevant to replenishment and maintenance. In short, Timaeus aims to give an account of "the replenishing system." So understood, the remarks on plants are a crucial part of the project of this passage, and accordingly the relevant Greek text for any discussion of it should run from 77a–81e.[8]

At the centre of this account of bodily replenishment and maintenance is a striking "fish trap" analogy. Timaeus describes a certain construction of fire and air currents that surrounds the human body, which he likens to a fish trap. Call this construction the "respiratory fish trap." It is the respiratory fish trap's motion that underlies the more intuitive parts of the replenishing system, i.e., digesting food and distributing the resulting "replacement matter" throughout the body. Commentators have generally focused directly on the workings of the respiratory fish trap without starting from the arguably prior question of how we should understand the fish trap analogy *qua* analogy. The resulting accounts of the respiratory fish trap thus proceed without considering whether and how our understanding of the respiratory fish trap should be informed by the analogy itself.[9] But in order to understand correctly the respiratory fish trap's motion and, by extension, the replenishing system as a whole, we need to understand the fish trap analogy, or so I shall argue. For not only is it the case that the respiratory fish trap is made for and ensures the replenishment of the body; once we understand how the analogy of the

8 Rather than 77c–81e, as e.g., in Pelavski (2014) and Cornford (1937: 304). Although Cornford remarks on the relevance of the passage on plants to the subsequent discussion (cf. his comments on plants, p. 302), he nevertheless treats the discussion as ranging from 77c to 81e (p. 304), presumably because he takes the unifying strand to be the mechanical solution to "a problem of hydraulics (ὑδραγωγία)" – viz., "how does the blood rise to the head and get distributed all over the body?" – rather than an account of bodily maintenance (1937: 303).

9 Those who comment (explicitly or implicitly) on the analogy *qua* analogy tend either to take the fish trap analogy as a straightforwardly descriptive image (Brisson 2001; Cornford 1937; Pelavski 2014) or to focus on two uncontroversially analogous features, acknowledging possible disanalogies but not examining further any problematic implications these might have (Karfík 2012).

fish trap works, we see that the analogy itself further illustrates and explains important features of this replenishing system.[10]

Accordingly, the central interpretive component of my case for 77a–81e as an account of the replenishing system is an account of the fish trap analogy. In section 2, I develop a proposal for how we should understand both the analogy and the system this analogy is supposed to illuminate. On this proposal, we should consider parts of the respiratory fish trap as *functional analogues* of the corresponding parts of the fisherman's fish trap.[11] Once we have a good sense of the components and motion of the respiratory fish trap, it becomes clear that the analogy of the fish trap picks out only the aspects and features of respiration, digestion, and circulation that are relevant to replenishment: the image of the fish trap is ideally suited to model and explain not the respiratory system, but the replenishing system. In other words, both the workings of the fish trap-mechanism in our body and this very choice of analogy support my overall reading of 77a–81e. Moreover, if the reconstruction of the fish trap analogy and the respiratory fish trap's motion that I develop in section 2 is right, the Timaean account of the respiratory fish trap does, in fact, have resources to explain the change in direction in the flow of air that we experience in inhalation and exhalation.

In section 3, I turn to the broader significance of my reading. In particular, I consider how the fish trap's motion contributes to our understanding of the reason-and-necessity explanatory framework as applied to the human body, of Timaean natural philosophy more generally, and of related issues in ancient physical science. I begin with independent considerations in favour of my reading of 77a–81e in light of

10 The focus on *bodily metabolism* (cosmic and human) in Betegh (2020); Karfík (2012), and in particular the tight connection between metabolism and the human body in a condition of health as opposed to disease in Betegh (2020), points to an understanding of the overall passage that is quite similar to mine, though it is also compatible with Cornford's general focus on mechanics and understanding of the respiratory fish trap as the solution to a mechanical problem. Karfík (2012) includes a brief but exceedingly helpful overview of the fish trap's mechanism and its importance for replenishment, and seems to presuppose that bodily replenishment is the unifying concern of the passage. My account differs from Karfik's, however, over the best understanding of the analogy, its role and importance for understanding the account of bodily maintenance, and the status and scope of principles of motion.

11 Though Pelavski (2014) also offers a "functional" reading of the analogy, our accounts both of the analogy and of the design and functioning of the respiratory fish trap have little in common. In brief, Pelavski's understanding of the fish trap is "functional" in the sense that he begins from the functions that modern anatomy takes the digestive and the respiratory apparatus to have, positing these organic functions as the relevant explananda that motivate Timaeus to introduce the fish trap (see esp. pp. 63–6). Pelavski then proceeds to reverse-engineer the respiratory fish trap's design and motion accordingly. By contrast, my proposed reading of the fish trap analogy is functional in that it proceeds from the functions of different parts of the fisherman's fish trap. I discuss the consequences of different readings of the analogy in more detail in section 2.

the remaining formal and substantive problems and puzzles for the passage mentioned above. The proposed reading of both the passage as a whole and the fish trap analogy not only lends greater unity to the passage, both internally and within its immediate context in the dialogue, but also finds greater coherence and explanatory adequacy than has often been recognized. The paper ends by considering the significance of the account developed here for our understanding of two more specific principles in Timaeus' explanatory framework, viz. like-to-like motion and circular thrust.

2 The Fish Trap Analogy and the Respiratory Fish Trap

As far as we know, the fisherman's fish trap (κύρτος) that underlies the analogy consists of a vessel (κύτος) whose opening is sealed off by a funnel-like construction (ἐγκύρτιον).[12] This funnel-like ἐγκύρτιον, which Cornford describes as "a passage in the form of a truncated cone," is designed so as to admit fish into the vessel but prevent their escape in the opposite direction.[13] The target of the analogy, the "respiratory fish trap," is first introduced as follows:

> τούτοις οὖν κατεχρήσατο ὁ θεὸς εἰς τὴν ἐκ τῆς κοιλίας ἐπὶ τὰς φλέβας ὑδρείαν, πλέγμα ἐξ ἀέρος καὶ πυρὸς οἷον οἱ κύρτοι συνυφηνάμενος, διπλᾶ κατὰ τὴν εἴσοδον ἐγκύρτια ἔχον, ὧν θάτερον αὖ πάλιν διέπλεξεν δίκρουν· καὶ ἀπὸ τῶν ἐγκυρτίων δὴ διετείνατο οἷον σχοίνους κύκλῳ διὰ παντὸς πρὸς τὰ ἔσχατα τοῦ πλέγματος. τὰ μὲν οὖν ἔνδον ἐκ πυρὸς συνεστήσατο τοῦ πλοκάνου ἅπαντα, τὰ δ' ἐγκύρτια καὶ τὸ κύτος ἀεροειδῆ.
>
> So the god used these [air and fire] for the watering from the belly to the blood vessels, having woven together in the manner of fish traps a network out of air and fire with two ἐγκύρτια along its entrance, one of which he once again wove as bifurcated. And from the ἐγκύρτια he extended them like reeds in a circle throughout the whole to the limits of the web. He put together all the internal parts of the basket out of fire, and the ἐγκύρτια and the vessel he made of air (78b2–c2).

12 Cornford's discussion of the fisherman's fish trap continues to be the most detailed; for helpful discussion of and references to our sources regarding relevant historical fish traps, cf. Cornford (1937: 308–311). Following his overview of ancient evidence about the fish trap, Cornford concludes (against Galen) that the ἐγκύρτιον is "the essential feature differentiating the weel [i.e., the fish trap] from other baskets, namely the cone-shaped funnel" (p. 310). Cf. perhaps *Soph.* 220c4–9, where the Eleatic Stranger divides hunting of the underwater-kind (i.e., fishing) into hunting by means of enclosures and hunting by means of striking and mentions κύρτοι in the description of the former.

13 Cornford (1937: 309).

As Timaeus describes it, the respiratory fish trap in and around our bodies has two ἐγκύρτια and a κύτος (a vessel) that are made of air. In the ensuing discussion, the vessel is also called a πλόκανον (a basket, or similar wicker work) and a πλέγμα (a network, something that is woven or plaited together). The parts of the basket that are inside the human body are said to be made of fire, in contrast to the airy vessel on the outside and the airy ἐγκύρτια. The two ἐγκύρτια are themselves further divided and organized in a somewhat complicated way, but the main point seems to be that the ἐγκύρτια, or branches of an ἐγκύρτιον, go from the mouth and nose into the lung down along the windpipe (κατὰ τὰς ἀρτηρίας) as well as into the belly alongside the windpipe (παρὰ τὰς ἀρτηρίας) (78c3–d1). The airy vessel, in turn, is placed around the trunk of our body (specifically, around "as much of us as is hollow," 78d2).

It is tempting to grasp for mental images and "ways of visualizing" at this point: few of us spend much time thinking about either the human respiratory system or ancient Greek fish traps, and the above description may not seem particularly informative. To be sure, representations of the fisherman's fish trap (and perhaps even speculative visual reconstructions of the respiratory fish trap)[14] can help situate the analogy for those of us who are not experts on fish traps, and can help us get some initial grip on the kind of thing Timaeus is talking about. But, as I shall argue shortly, caution in visualizing the respiratory fish trap can help us steer clear of potentially far-reaching interpretive pitfalls.[15]

There are two analogous features that, on their own, may safely be visualized: the spatial organization of the matter that constitutes each of the two kinds of fish trap and what we may call the mutual interpenetrability between each fish trap and

14 As e.g., in Cornford (1937: 311–13), 'Annexe 9' in Brisson (2001: 309), Joubaud (290–1, Fig. 1–2).

15 Contrast Pelavski's view, according to which the interpreter's task in this context seems to be primarily one of facilitating visualization or developing a way of visualizing the respiratory fish trap: "Considering that this section of the dialogue (much like the rest) is full of descriptive images, my aim is to try to visualise these κύρτος-like organs through a new interpretation of this obscure passage", Pelavski (2014: 62); 'visualise' and 'visualisation' appear nine times in the articles' 13 pages. Similarly, p. 65: "For readers, one of the key difficulties of this passage is to visualise the organs described." Cornford (1937: 308), in turn, not only encourages visualization, but takes the text to do the same: "The next sentences … are to be understood as if Plato were drawing a picture, the lines of which stand for the routes followed by currents of air and fire" (*ad* 78b, p. 310). In fact, Cornford's suggested approach is to try to start from the fisherman's fish trap *in order to draw correctly a corresponding diagram* of the respiratory fish trap: "*In order to reconstruct Plato's diagram of the currents*, it is necessary first to be clear about the construction of the fish-trap or weel (κύρτος, Lat. *nassa*) and the meaning of ἐγκύρτιον, above translated 'funnel'" (*ad* 78b, p. 310; my emphasis). Against this background, it is not surprising that Cornford focuses only on the spatial organization of fire and air suggested by the analogy. (It may be worth noting that we are not explicitly invited to visualize a fish trap, unlike elsewhere in Plato; cf., to take an extreme example, forms of ὁράω in the Allegory of the Cave, *Rep*. 514a ff.; rather, Timaeus simply starts using fish trap vocabulary to distinguish and refer to parts of the analogous system in and around the human body.)

certain types of matter. Both are respects in which the analogy is relatively straightforwardly informative. The first, i.e., the spatial organization of the matter constitutive of the fish trap, enables Timaeus efficiently to distinguish, label, and refer to different parts of the respiratory fish trap throughout the passage: the ἐγκύρτια pick out the air that enters the body through the mouth and nose, while the vessel picks out the air that surrounds and moves through our trunk.

The second obvious parallel is penetrability. Being plaited or woven together is a key feature of both the literal and the respiratory fish trap alike, and the resulting interstices allow for mutual interpenetrability of the respiratory fish trap and certain types of matter. Indeed, the respiratory fish trap is constructed out of fire and air in order to ensure this (78a2–b2):

> πάντα ὅσα ἐξ ἐλαττόνων συνίσταται στέγει τὰ μείζω, τὰ δὲ ἐκ μειζόνων τὰ σμικρότερα οὐ δύναται, πῦρ δὲ πάντων γενῶν σμικρομερέστατον, ὅθεν δι' ὕδατος καὶ γῆς ἀέρος τε καὶ ὅσα ἐκ τούτων συνίσταται διαχωρεῖ καὶ στέγειν οὐδὲν αὐτὸ δύναται. ταὐτὸν δὴ καὶ περὶ τῆς παρ' ἡμῖν κοιλίας διανοητέον, ὅτι σιτία μὲν καὶ ποτὰ ὅταν εἰς αὐτὴν ἐμπέσῃ, στέγει, πνεῦμα δὲ καὶ πῦρ σμικρομερέστερα ὄντα τῆς αὐτῆς συστάσεως οὐ δύναται.
>
> All things that are constituted out of smaller [parts] hold in greater [things], but things that are [constituted] out of greater [parts] cannot hold in smaller [things], and fire has the smallest parts of all the kinds, which is why it can pass through water, earth, air, and things constituted out of these [three], and [why] nothing can contain it. One must think the same also in the case of our belly, [viz.] that whenever food and drink fall into it, it holds [them] in, but it cannot hold in air and fire since they are of smaller parts than its own constitution (78a2–b2).[16]

The mutual interpenetrability between the respiratory fish trap and parts of the human body is thus analogous to the mutual interpenetrability of the fisherman's fish trap and the water in which it is placed.[17]

Once we move beyond spatial organization and mutual interpenetrability, however, trying to visualize the respiratory fish trap may easily mislead us, perhaps especially when taking representations of the fisherman's fish trap as an inspiration

16 'Air' here renders πνεῦμα. I agree with Karfík (2012): 171, n. 33) that πνεῦμα and ἀήρ are interchangeable in this passage. (For an illustrative case, cf. 78b1–5.)

17 Karfík (2012: 176) takes the point of the analogy to be limited to spatial organization and mutual penetrability: "[The apparatus'] comparison with the *nassa* [fish trap] is suitable mainly for two reasons. First, the *nassa* is provided with a cone-shaped funnel (ἐγκύρτιον) which can be compared to the pipes leading from mouth and nose down into the trunk, i.e., to channels through which the current of the respiratory air—the proper object of the description here—passes […]. The second reason is that the *nassa* is immersed into water which, in its turn, penetrates the *nassa*. The body of the *nassa* and the mass of water into which it is immersed are like two bodies pervading each other."

or guide. Indeed, insofar as mutual interpenetrability is *selective*, this feature may seem to give rise to problems for the analogy: mutual interpenetrability matters for the fisherman's fish trap in the form of selective containment – letting water through its interstices while keeping fish inside. By contrast, the respiratory fish trap is not in the business of containing anything at all, selectively or not. Rather, the human body (in particular the belly) contains food while allowing the vessel of the respiratory fish trap to pass through its pores. We may put a related concern in terms of motion: intuitively, the vessel of the fisherman's fish trap is penetrated by water, but Timaeus says of the vessel of the respiratory fish trap that *it* penetrates the body. That is, while water moves into and out of the vessel of a fisherman's fish trap through the vessel's interstices, it is the respiratory vessel *itself* that moves into and out of the human body through the *body's* interstices:

> τὸ δὲ ἄλλο κύτος τοῦ κύρτου περὶ τὸ σῶμα ὅσον κοῖλον ἡμῶν περιέφυσεν, καὶ πᾶν δὴ τοῦτο τοτὲ μὲν εἰς τὰ ἐγκύρτια συρρεῖν μαλακῶς, ἅτε ἀέρα ὄντα, ἐποίησεν, τοτὲ δὲ ἀναρρεῖν μὲν τὰ ἐγκύρτια, τὸ δὲ πλέγμα, ὡς ὄντος τοῦ σώματος μανοῦ, δύεσθαι εἴσω δι' αὐτοῦ καὶ πάλιν ἔξω.
>
> And he made the rest of the vessel of the fish trap grow around as much of us as is hollow, and he brought it about that all this at one time flows together gently – seeing as it is air – into the ἐγκύρτια, while at another time the ἐγκύρτια flow back, and since the body is porous, the network sinks through it to the inside and again to the outside (78d1–d6).

The passage quoted above may seem to point to another disanalogous feature. *Prima facie*, the design of the fisherman's fish trap, and in particular of its funnel-shaped ἐγκύρτιον, suggests that the ἐγκύρτια of respiratory fish traps are *passages* or *channels* for air currents, i.e., passages or channels through which air currents flow. Here too, assimilating the respiratory fish trap too closely to the fisherman's fish trap and visualizing the respiratory fish trap as a respiratory organ (in the sense of a bodily, tissue-like structure) can lead to potentially problematic disanalogies. For unlike the ἐγκύρτια of fishermen's fish traps, which are indeed passages through which currents of water flow, the ἐγκύρτια in respiratory fish traps *are* currents of air molecules, not the channels through which these molecules move. That, I take it, is why the ἐγκύρτια are said to be placed κατά and παρά the windpipe as opposed to their *being* the windpipe.[18] The currents of water in a fisherman's fish trap and the currents of air in respiratory fish traps may thus seem to be disanalogous (even if spatially organized in similar ways) because water

18 Compare (Karfík 2012: 175): "The *nassa* is provided with a cone-shaped funnel (ἐγκύρτιον) which can be compared to the pipes leading from mouth and nose down into the trunk, i.e., *to channels through which the current of the respiratory air*—the proper object of the description here—*passes*" (my italics).

flows through the ἐγκύρτια of the fisherman's fish trap, whereas air *constitutes* the ἐγκύρτια of the respiratory fish trap.

This latter tension dissolves, however, if we consider the ἐγκύρτια as functionally equivalent. It is true that the respiratory fish trap's ἐγκύρτια are constituted out of the moving element, air. They are nevertheless functionally analogous to the ἐγκύρτιον of a fisherman's fish trap insofar as they are the means by which the element that is in motion moves into and out of the fish trap – air in one case, water in the other. In the respiratory fish trap, the air is itself in motion – that is, currents of air that carry their constitutive air molecules along with them. This helps make sense of parts of the text where Timaeus speaks both of air flowing *into* the ἐγκύρτια and of the ἐγκύρτια *themselves* flowing back (cf. 78d1–d6, quoted above). By contrast, when trying to visualize the respiratory fish trap on the basis of the fisherman's fish trap, it is easy to end up with a mental image that builds in the (quite natural, but unwarranted) assumption that a pathway or channel must be constituted out of something distinct from that which flows through the channel or from that which goes along the pathway. One may thus easily think of the ἐγκύρτια as pipes or channels for air rather than currents of air; likewise, one may easily imagine the structure as "fixed" in such a way that its interstices can be penetrated (whatever that amounts to in a plenum universe), rather than thinking of the plaited construction as being itself in motion. Both features contribute to worries about relevantly disanalogous features that need not arise if the vessel and ἐγκύρτια of the respiratory fish trap are considered as the *functional* analogues of the relevant parts of the fisherman's fish trap.

The proposal, then, is to understand the fish trap analogy functionally. More specifically, the idea is to consider parts or aspects of the fisherman's fish trap that have analogues in the respiratory fish trap, and to think of them as functional analogues. So, for example, the ἐγκύρτια of respiratory fish traps are functional analogues of the ἐγκύρτιον of a fisherman's fish trap insofar as they are means and passages by which the element that is in motion moves into and out of its respective fish trap (air in the case of the respiratory fish trap, water in the case of the fisherman's fish trap). Likewise, the plaited design and material constitution of the respiratory fish trap's vessel is functionally analogous to the wicker basket of the fisherman's fish trap insofar as these aspects of the vessel underlie the mutual interpenetrability of the fish trap with certain kinds of matter, thus allowing the element in motion (air and water, respectively) to move into and out of the inside of the fish trap.

Thinking of these parts of the respiratory fish trap as functional analogues thus preserves the informative parallels of spatial layout and mutual interpenetrability without giving rise to the potentially worrying features discussed above. For the kind of functional reading proposed here does not suggest that the channels by

means of which currents of air or water move to the inside of the fish trap are distinct from the currents that so move. By contrast, a reading that analogizes exclusively the structure of the fisherman's fish trap more naturally suggests that the channels are distinct from the currents that move by means of these channels.

The reading proposed here also differs from other approaches to the analogy that focus on the notion of function. In particular, my reading differs from functional readings that take as their starting point (i) the primary function of the fisherman's fish trap (viz., catching fish), (ii) the primary function of the respiratory fish trap (viz., ensuring the continued replenishment and maintenance of the human body), or (iii) the primary function of relevant bodily structures as physicians and biologists *today* understand them, along the lines of the functional reading developed in Pelavski (2014).[19] As a brief illustration, consider how, for all that has been said so far, one might wonder about the respiratory analogue of *fish* – or, to return to the first concern mentioned above, one might wonder whether the *selective containment* of the fisherman's fish trap points to an important disanalogy. As mentioned above, the respiratory fish trap is not in the business of containing anything; put even more bluntly, it is not really a *trap*. We are told that the parts on the inside of the respiratory fish trap's vessel are made of fire, but this fire is not contained by the trap in the sense that the trap's construction prevents it from leaving. There is, of course, something that "goes into" the respiratory fish trap, viz. air; but the currents of air are more naturally taken as analogous to the currents of water in the fisherman's fish trap, which also move in and out of the trap. However, I propose analogizing not the function of the fisherman's fish trap

19 Pelavski introduces the idea of function in the context of discussing the functions that we (today) take various organs to have and indeed begins his account of the respiratory fish trap by framing the explananda in modern anatomical terms: "In order to comprehend this passage in detail, it is useful first to consider the difficulties it presents in the light of current scientific knowledge" (2014: 64). On the basis of a (modern) description of both the digestive and the respiratory apparatus (pp. 64–5), Pelavski concludes that "Timaeus therefore aims here to present his understanding of a group of organs which are contiguous with each other and with the environment, and whose function is to receive elements from outside the body, process them (digestion and respiration), and carry them into the blood (absorption and oxygenation)" (p. 65). It is against this backdrop that we must understand Pelavski's subsequent use of 'functional tissue' (p. 65) and, importantly, "the hypothesis that the analogy is primarily functional" (p. 66). This is especially clear when he contrasts his own "functional" reading of the analogy with Cornford's focus on the fish trap's shape: "Cornford and his followers seem to be more interested in making sense of the shape, rather than the function, of the κύρτος, despite the fact the lobster-pot model, taken literally, can be hardly reconciled with an actual human body" (p. 66). By contrast, on my reading, there is much more to the fish trap analogy than spatial organization, but the shape of a fisherman's fish trap may nevertheless be informative; minimally, my reading is not supposed to *exclude* a certain similarity in shape.

(which is, of course, to catch fish), but rather, given the overall function of the fisherman's fish trap, the function of those parts of it in terms of which Timaeus describes the respiratory fish trap. There is therefore no analogue of fish in the case of the respiratory fish trap, and indeed there need not be one. By contrast, a functional reading that takes its cue from the overall function of the fisherman's fish trap would presumably require a suitable analogue of fish.

Though my proposed reading of the analogy does not require it, it is compatible with considering the fire and hot air inside the respiratory fish trap as analogous to fish. To see how and why this is the case, however, we must first turn to the fish trap's motion. I return to implications of and for my proposed reading of the analogy at the end of this section, once my account of the respiratory fish trap's motion is in place.

*

Timaeus explains the motion of the respiratory fish trap in terms of two principles of motion. One is a principle specifically of motion in a plenum that commentators often call *periōsis*, sometimes translated as "circular thrust". The standard example for illustrating circular thrust is the motion of a projectile in a plenum. The idea is that a projectile can move through the air in a plenum because it displaces the air in front of it, which doubles back to push the projectile further in the direction in which it is moving. Timaeus describes circular thrust in the case of the respiratory fish trap as follows (79b1–c1):

> ἐπειδὴ κενὸν οὐδέν ἐστιν εἰς ὃ τῶν φερομένων δύναιτ' ἂν εἰσελθεῖν τι, τὸ δὲ πνεῦμα φέρεται παρ' ἡμῶν ἔξω, τὸ μετὰ τοῦτο ἤδη παντὶ δῆλον ὡς οὐκ εἰς κενόν, ἀλλὰ τὸ πλησίον ἐκ τῆς ἕδρας ὠθεῖ· τὸ δ' ὠθούμενον ἐξελαύνει τὸ πλησίον ἀεί, καὶ κατὰ ταύτην τὴν ἀνάγκην πᾶν περιελαυνόμενον εἰς τὴν ἕδραν ὅθεν ἐξῆλθεν τὸ πνεῦμα, εἰσιὸν ἐκεῖσε καὶ ἀναπληροῦν αὐτὴν συνέπεται τῷ πνεύματι, καὶ τοῦτο ἅμα πᾶν οἷον τροχοῦ περιαγομένου γίγνεται διὰ τὸ κενὸν μηδὲν εἶναι.
>
> Since there is no void into which any of the things that are being carried could enter, and breath moves from us to the outside, as to what happens after this, it is now clear to everyone that it does not move into the void but it displaces what is next to it. And in each case what is being pushed out drives out what is next to it, and in accordance with this necessity, everything, being pushed around into the space that breath left, follows breath by entering that place and re-filling it, and all this happens at the same time, like a wheel that is being turned around, since the void does not at all exist (79b1–c1).

The second principle is the perhaps more familiar principle of like-to-like motion: elemental molecules move towards their own kind and their natural place. Timaeus notes explicitly both the generality of the principle and its application in this context: "And the manner of the filling and emptying comes to be just as the movement [φορά] of everything in the all came to be, [the motion with which]

everything that is akin moves towards itself" (81a2–4). As far as the workings of the respiratory fish trap are concerned, Timaeus calls it "the *aitia* of the *archē* of these things" (79c7–d1).

We see both of these principles at work in the following description of the respiratory fish trap's motion:

> τὸ θερμὸν δὴ κατὰ φύσιν εἰς τὴν αὐτοῦ χώραν ἔξω πρὸς τὸ συγγενὲς ὁμολογητέον ἰέναι· δυοῖν δὲ τοῖν διεξόδοιν οὔσαιν, τῆς μὲν κατὰ τὸ σῶμα ἔξω, τῆς δὲ αὖ κατὰ τὸ στόμα καὶ τὰς ῥῖνας, ὅταν μὲν ἐπὶ θάτερα ὁρμήσῃ, θάτερα περιωθεῖ, τὸ δὲ περιωσθὲν εἰς τὸ πῦρ ἐμπῖπτον θερμαίνεται, τὸ δ' ἐξιὸν ψύχεται. μεταβαλλούσης δὲ τῆς θερμότητος καὶ τῶν κατὰ τὴν ἑτέραν ἔξοδον θερμοτέρων γιγνομένων πάλιν ἐκείνῃ ῥέπον αὖ τὸ θερμότερον μᾶλλον, πρὸς τὴν αὐτοῦ φύσιν φερόμενον, περιωθεῖ τὸ κατὰ θάτερα.
>
> One must agree that the hot by nature goes outside to its own place towards what is akin to it. Seeing as there are two pathways, one through the body to the outside, the other through the mouth and nose, whenever there is a rush towards the one, the other pushes around, and what has been pushed around falls upon fire and is heated, while what goes outside is cooled. As the heat changes and as those along one or the other exit become hotter, the hotter, inclining rather once more to that [exit] and being carried towards its own nature, pushes around what is along the other [exit] (79d5–e6).

Very roughly, then, the idea is this: When we breathe in air through the mouth and nose, what we inhale is heated when it encounters our internal fire, as every animal has a certain internal heat (cf. 79d1–2). The heated air, driven by fire seeking its cosmic like, then leaves the body in the same way in which it entered (in this case, through the mouth and nose), and so we exhale. (It is this air that we breathe in and out through our mouth and nose that constitutes the airy ἐγκύρτια in Timaeus' initial description of the respiratory fish trap.) Once outside the body, the current we have just exhaled cools down. Importantly, exhaling this current causes the air molecules that constitute the airy vessel of the fish trap to be pushed through the pores of our trunk to the inside of our body. This air, too, is heated inside before leaving the body, and here, too, the heated air leaves by the same route by which it entered (i.e., through the body's pores). This movement of the airy vessel to the outside of the body pushes air up and through our mouth and nose, i.e., causes us to inhale—and so we have come full circle.

We are now in a better position to understand how the regular movement of air currents underlies replenishment (78e5–79a4):

> ὁπόταν γὰρ εἴσω καὶ ἔξω τῆς ἀναπνοῆς ἰούσης τὸ πῦρ ἐντὸς συνημμένον ἕπηται, διαιωρούμενον δὲ ἀεὶ διὰ τῆς κοιλίας εἰσελθὸν τὰ σιτία καὶ ποτὰ λάβῃ, τήκει δή, καὶ κατὰ σμικρὰ διαιροῦν, διὰ τῶν ἐξόδων ᾗπερ πορεύεται διάγον, οἷον ἐκ κρήνης ἐπ' ὀχετοὺς ἐπὶ τὰς φλέβας ἀντλοῦν αὐτά, ῥεῖν ὥσπερ αὐλῶνος διὰ τοῦ σώματος τὰ τῶν φλεβῶν ποιεῖ ῥεύματα.

> For whenever the internal fire, having been connected with the inhalation as it goes in and out, follows it, and, constantly moving to and fro, goes in through the belly and takes food and drink, it melts them down and, cutting them into small [parts], leading them through the exits where it moves, and drawing them into the blood-vessels like out of a spring into the channels, it makes the currents of the blood-vessels flow through the body just as through a pipe (78e5–79a4).

The fish trap's motion involves the continued motion of fire molecules in different directions: the fiery internal parts of the fish trap move up and down through the belly as they follow the regular movement of air, seeking their cosmic like outside the body. In the process, fire molecules chop up food in the belly and lead the resulting bits into the blood vessels. These bits are then transported via the bloodstream to any parts of the body that need to be repaired and replenished.[20] Notably, like-to-like motion serves as a (partial) explanation of all three of these key steps in replenishment: it is in virtue of like-to-like motion that (1) the plants we have eaten are chopped up into bits as fire molecules move up and down through our belly, (2) that these plant-bits end up in the bloodstream as replacement parts, and (3) that these replacement parts in the blood move to appropriate sites of depletion (81a1–b3). This last point underscores why it is so important that plants are made up of stuff that is συγγενής to us, as Timaeus himself reminds us at key junctures (cf. 77a3–4, 80d8).

This basic picture of the fish trap's motion does not yet enable us to address any of the interpretive challenges mentioned earlier, so let us now take a closer look at the fish trap's motion with an eye to some of these challenges. In what follows, I argue that the heating and cooling of air currents should be understood in terms of limited intertransformations of fire and air molecules, chiefly on the grounds that the respiratory fish trap is best understood as a closed system in a material or constitutive sense. If this reconstruction of the respiratory fish trap's motion and its constituent matter is correct, then the Timaean account may have resources to explain the change in direction of air flow when we inhale and exhale, in contrast to interpretations on which we must simply assume that air enters and leaves by the same route as opposed to continuing to be pushed in the same direction (as, e.g., on Cornford's reconstruction).

As we saw in 79d5–e6 (quoted in full above), the respiratory fish trap's motion involves air currents being pushed inside the body, where it "falls upon fire and is heated, whereas what goes outside is cooled" (εἰς τὸ πῦρ ἐμπῖπτον θερμαίνεται, τὸ δ' ἐξιὸν ψύχεται, 79e2–3). The heating and cooling of the fish trap's air currents, as

20 Cf. the later passage 80d3–6, where Timaeus summarizes the job description of fire as "cutting up the food, and, rising up inside, following breath, and, along with the rising, filling the blood-vessels from the belly by pouring the things that have been cut."

well as the resulting (if very temporary) hot and cold air currents, are best understood as resulting from, in the first place, the intertransformations between air and fire molecules: when the air currents are heated inside the body, some of the current's constituent air molecules transform into fire molecules; when the hot air cools down outside, these fire molecules subsequently transform into air molecules.[21] On an alternative view, the heating and cooling of the fish trap's air currents should instead be understood primarily in terms of air molecules mingling with fire molecules inside the body and separating from these fire molecules outside the body. The main reason for preferring the former account of heating and cooling (certainly in this context) is related to a feature of the fish trap that comes out in Timaeus' explanation of why replenishment comes to an end, resulting in old age and ultimately death. In 81b–d, we learn that the "root" of the triangles that constitute our internal fire molecules becomes loose as the result of chopping food over a prolonged period of time:

> τὰ δὴ περιλαμβανόμενα ἐν αὐτῇ τρίγωνα ἔξωθεν ἐπεισελθόντα, ἐξ ὧν ἄν ᾖ τά τε σιτία καὶ ποτά, τῶν ἑαυτῆς τριγώνων παλαιότερα ὄντα καὶ ἀσθενέστερα καινοῖς ἐπικρατεῖ τέμνουσα, καὶ μέγα ἀπεργάζεται τὸ ζῷον τρέφουσα ἐκ πολλῶν ὁμοίων. **ὅταν δ' ἡ ῥίζα τῶν τριγώνων χαλᾷ διὰ τὸ πολλοὺς ἀγῶνας ἐν πολλῷ χρόνῳ πρὸς πολλὰ ἠγωνίσθαι, τὰ μὲν τῆς τροφῆς εἰσιόντα οὐκέτι δύναται τέμνειν εἰς ὁμοιότητα ἑαυτοῖς, αὐτὰ δὲ ὑπὸ τῶν ἔξωθεν ἐπεισιόντων εὐπετῶς διαιρεῖται·** φθίνει δὴ πᾶν ζῷον ἐν τούτῳ κρατούμενον, γῆράς τε ὀνομάζεται τὸ πάθος. τέλος δέ, ἐπειδὰν τῶν περὶ τὸν μυελὸν τριγώνων οἱ συναρμοσθέντες μηκέτι ἀντέχωσιν δεσμοὶ τῷ πόνῳ διιστάμενοι, μεθιᾶσιν τοὺς τῆς ψυχῆς αὖ δεσμούς, ἡ δὲ λυθεῖσα κατὰ φύσιν μεθ' ἡδονῆς ἐξέπτατο.

> Now, as the triangles that are in the process of being included in [the animal's constitution] – those out of which food and drink are composed – have come in as additions from outside and are older and weaker than its own triangles, it cuts them up and overpowers them by means of [its] new triangles and makes the animal large by nourishing it from similar things. **But when the root of the triangles becomes loose on account of having fought many battles against many things over the course of much time, they are no longer able to cut the incoming [bits] of food into their likeness, but they themselves are easily divided by those coming in from the outside.** Every animal wastes away when it is conquered in this [battle], and this affection is called 'old age'. And finally, when the bonds of the triangles around the marrow, which have been fitted together, no longer resist being separated by toil,

21 Earlier in the dialogue, Timaeus identifies two types of triangles as the ultimate constituents of material particulars, the right-angled isosceles triangle and the half-equilateral triangle. Molecules of the four traditional elements are identified with four of the five "Platonic solids," which are in turn composed out of the basic triangles. Molecules of fire (tetrahedra) and air (octahedra), along with water molecules (icosahedra), all have half-equilaterals as their constituent triangles and can inter-transform through the separation and combination of like parts. For more detail, see esp. *Tim*. 53b5–57c6.

> they set loose again the bonds of the soul, and it flies off with pleasure, having been released in accordance with nature (81c2–e1).

Whatever exactly it means for the "root" of the triangles to weaken and become loose, we know at least two things: first, that it has the result that the fire molecules in our belly can no longer cut up the incoming food particles into new material bits that can replenish the body; and second, that this fatal weakening is due to all the digestive battles that fire in our belly has been fighting over time (διὰ τὸ πολλοὺς ἀγῶνας ἐν πολλῷ χρόνῳ πρὸς πολλὰ ἠγωνίσθαι, 81c7–d1).

The important take-away for the purposes of this paper is that the triangles' cutting activity over the course of an extended period of time is the only reason Timaeus gives for why replenishment comes to an end. The same triangles cut many things for a long time, even if they do so as part of many different fire molecules. This suggests that the fish trap is a closed system in the sense that its material constituents remain constant.[22] The fiery parts of the fish trap move up and down inside our body as they follow incoming and outgoing currents of air (78d6–7, 78e5–7, 80d3–4).[23] Moreover, some air molecules change into fire upon encountering and being heated by fiery parts inside the body, and some fire molecules leave the body as part of the heated, outgoing air current and change into air once outside the body. But the triangles involved in these changes are the same throughout. While most of our body is continually depleted by the environment and replenished by our blood, the fish trap – conceived of in terms of its constituent triangles – is neither depleted nor replenished with fresh triangles throughout someone's life. (That triangles are designed to have an expiration date is hinted more explicitly later in the dialogue, at 89c1–4.) Minimally, it can be depleted and/or replenished only partially, to an extent that is compatible with Timaeus' explanation that replenishment ceases because the fire triangles have become too old and weak to cut up food. For these reasons, it seems that the

22 Betegh (2020) likewise speaks of the respiratory fish trap as a closed system, though his description is compatible with a conception of it as a closed system both (i) in the material/constitutive sense outlined above, and (ii) in the sense that, given a plenum universe, its motion is self-contained. On my account, the fish trap's motion turns out to be (more or less) self-contained as well, but what matters for the account of bodily maintenance is its being a closed system in the material/constitutive sense, as should be clear from Timaeus' explanation of aging and death.

23 τὰς δὲ ἐντὸς τοῦ πυρὸς ἀκτῖνας διαδεδεμένας **ἀκολουθεῖν** ἐφ' ἑκάτερα ἰόντος τοῦ ἀέρος (78d6–7); ὁπόταν γὰρ εἴσω καὶ ἔξω τῆς ἀναπνοῆς ἰούσης τὸ πῦρ ἐντὸς συνημμένον **ἕπηται** (78e5–7); τῷ πνεύματι **συνεπομένου** (80d3–4).

respiratory fish trap is best understood as a closed system in a material/constitutive sense.[24]

Understanding the heating and cooling of air currents primarily in terms of the intertransformation of air and fire molecules need not be in tension with Timaeus' initial description of the fish trap as having internal parts made of fire, an airy vessel, and airy ἐγκύρτια (78b7–c2). It is still the case that the ἐγκύρτια and the vessel consist primarily of air – they simply come to contain a growing number of fire molecules whenever their constitutive currents of air are heated inside the body. Indeed, this suggestion is in line with the way in which Timaeus refers to and describes non-homogenous material aggregates of molecules in terms of their dominant constitutive element throughout the dialogue (cf., for example, the varieties of water and earth discussed at 59e ff.).

According to the alternative view of heating in terms of mixing or mingling, the fire contained in our exhalation escapes to its like once outside the body – that is, it escapes the system as a whole. Cornford, for example, writes that "[w]hen the breath gets outside it encounters colder air, and the fire in it will presumably continue its journey and pass out of the expelled air".[25] It seems to follow from Cornford's reading that a person's internal fire is either replenished with new molecules or simply depleted over the course of her life (when measured by number of molecules). On the latter view, our internal heat would be used up at some point. Now, depletion

24 Why think that the *fish trap as a whole* is a closed system – why not think that it is simply the internal fiery part of the fish trap that is a closed system in this sense? *Prima facie*, it seems that Timaeus' explanation of old age and natural death requires only that the fiery part that moves up and down inside the belly cutting up food is a closed system in the material/constitutive sense. I find more natural a view on which the entirety of the fish trap is a closed system such that (i) the fire that cuts up the plants we have eaten can at least in principle incorporate some of the triangles that result when the incoming air is heated, and (ii) the heated air need not exclusively contain (as its fiery component) fire molecules that result from the transformation of air molecules, but may also include a few fire molecules that previously cut up food. That said, the text does not exclude a stricter division between the internal fire and any fire molecules that leave the body as part of heated air, such that not even a single triangle of the fiery parts that cut up food ever leaves the body. Any fire molecules that leave the body as part of hot air currents would be the result of air molecules transforming into fire molecules inside the body that, once outside, turn into air molecules. (Alternatively, the relevant fire molecules would have to escape to their like and be replaced by new air molecules in such a way that the overall back and forth motion of the fish trap continues undisturbed.) It is worth noting, however, that the text also does not give us any reason to think that there is a restriction on fire isotopes that cut food, or (more strongly) a restriction on the kinds of triangles that could make up the kind of fire that cuts food, i.e., a restriction that would explain why the internal heat could not even in principle be replenished by, or simply incorporate, any triangles that are not already part of it. In any case, neither understanding of the respiratory fish trap (or some part of it) as a closed system by itself speaks against the claim that the heating and cooling of the fish trap's air currents is best understood in terms of limited intertransformations between fire and air molecules.

25 Cornford (1937: 317).

of a person's internal fire would be quite a neat explanation of why we cannot replenish and maintain our bodies indefinitely: the furnace has run out, as it were. The problem is that Timaeus says no such thing; he instead points to triangles that have grown weak as the result of prolonged digestive battles. If, however, the internal fire were not just depleted, but also replenished with new triangles to any significant degree, it is unclear why it is that fire triangles growing old and weak should be the cause of natural death in the normal course of things.[26]

26 One might object to the above reconstruction along the following lines. Grant that, whatever heating and cooling of air involves, the text gives us good reason to think that the heating of air currents does not primarily consist in mingling with fire molecules of internal fire and that the cooling of air currents does not consist in the escape of those fire molecules from the entire system, whether with or without replenishment of the internal fire. But why should the fact that the fish trap is a closed system in this material/constitutive sense be a reason for thinking that heating and cooling of air involves the transformation of some limited number of air molecules into fire molecules (and vice versa)?

We know we need some account of the heating and cooling of air currents – something to explain comparatively cold air being heated inside the body and comparatively hotter air cooling down outside. To accommodate Timaeus' explanation of why replenishment comes to an end, we can also keep fixed that, minimally, the fire that cuts up food is a closed system in the sense that it is not supplied with new triangles and does not lose fire molecules to the outside such that it would eventually "run out". Moreover, note that, in general, molecular changes in the *Timaeus* can be analyzed in terms of an active party (the mover/changer) and a passive party (the moved/changed). The two must be dissimilar for any kind of change to come about: in a uniform aggregate, i.e., an aggregate of molecules of the same kind, molecules can neither act nor be affected (57e2–58a1; 57a3–5). When the relative amount, density, and distribution of two aggregates is held fixed, there seem to be some general patterns given by the comparative sizes of different molecules (56e7–57c6): an aggregate of smaller molecules affects an aggregate of larger molecules by cutting or separating it, something that is especially true of fire in relation to other elements; meanwhile, an aggregate of larger molecules prevails over an aggregate of smaller ones by surrounding it and crushing the smaller molecules. From the point of view of the "losing" side in such contests, there are only two options, each of which eliminates non-uniformity: molecules can either assimilate, i.e., intertransform (if possible) into molecules of the dominant kind, or escape to what is akin to them.

With this Timaean background in mind, consider what the heating and cooling of air currents might consist in. An account of air being heated as mingling with already existing fire molecules is problematic, since it suggests that the corresponding cooling process outside the body amounts to fire molecules separating from or leaving the air current, i.e., escaping to the environment, which we have assumed not to happen. The only other plausible alternative given the framework of Timaean physics is that the heating and cooling of air involves intertransformations. We know that heating is the effect of fire molecules on molecules of other elements, which generally involves fire molecules cutting up or otherwise separating other matter—if not by moving in between them (mingling), then by cutting up molecules into their constituent triangles, which go on to recombine in some form. When air currents are heated inside the body, these triangles plausibly combine into fire molecules, thus explaining why the current of air that we exhale is hot. Once outside the body, the cooling of hot air plausibly involves the crushing of fire molecules by the surrounding air, similar to the description of fire molecules turning into air molecules when crushed by surrounding air at 56e1–5.

There is a further interpretive advantage of understanding the heating and cooling of air currents in terms of limited intertransformations of air and fire molecules and taking these currents to be part of a larger closed system in the sense specified. A reconstruction of the respiratory fish trap along these lines can account for the seemingly *ad hoc* assumption that currents of air and fire enter and leave the body *via the same pathway*, i.e., either through the pores of our trunk or through the mouth and nose. While it is this assumption that ensures the change in direction that characterizes the familiar pattern of inhalation and exhalation, it is not clear what justifies it. Consider Cornford's assessment of this change in direction as it features in Timaeus' account: "[a]t this point the explanation becomes obscure, because it is tacitly assumed that the air which comes in through the pores must also go out through the pores and not join the current passing out through the mouth. Perhaps the assumption is tacit because it seems too improbable. Once it is made, the reversal can be explained" (1937: 317). In other words, in order to attribute to Plato a coherent explanation of the fish trap's motion, Cornford must, by his own admission, supply a crucial and seemingly unjustified assumption.[27] But the interpretive challenge lies not merely in offering an explanation of the change in direction, on the grounds that such an explanation seems preferable to the tacit assumption that there is such a change. Rather, the interpretive challenge (and the potential pay-off of meeting it) is that of providing an explanation instead of a *problematic* tacit assumption, given what Timaeus has explicitly told us about the selective penetrability and permeability of different kinds of matter. For the earlier explanation of why the respiratory fish trap consists of air and fire emphasizes precisely the point that air can pass through the interstices of bigger molecules of water and earth, and we have been given no reason to think that air would be held up by any body part.

A reading of the fish trap as a closed system in which air that enters the body gradually transforms into fire – i.e., an account of heating in terms of intertransformation rather than mingling – provides some reason for thinking that the current of molecules would enter and leave the body via the same route (either through mouth and nose or through the pores of the body's trunk). The air currents that are being heated and cooled constitute, and enter the body by means of, either the vessel or the ἐγκύρτια of the respiratory fish trap. In either case, the currents are

27 Cf. Cornford's remarks on the following page (1937: 318): "The obscurity lies in the next statement, because the assumption that air must go out by the same way that it came in is not openly made." (Aristotle's summary of the Timaean account, which Cornford approvingly quotes on p. 318, simply asserts that air enters and leaves via the same route without giving an explanation.) Pelavski posits small, balloon-like cul-de-sacs – as far as I can tell, rather reminiscent of alveoli (the tiny air sacs in our lungs we know from modern anatomy) – in order to explain the change in direction, despite the absence of textual evidence for such structures (2014: 69–70).

spatially extended, and their being heated upon entering the body means that there come to be fire molecules throughout the currents. These fire molecules eventually drive these currents back to the outside of the body as they seek their cosmic like. The easiest way to do this is via the route by which the currents of cool air entered, for the relevant route is the more direct route for the fire molecules that are part of, and spatially extended within, the (now hot) air current—the path of least resistance, as it were. Thinking of the heating of air currents in terms of limited transformations of air molecules into fire molecules thus offers a straightforward explanation of why air currents enter and leave the body via the same route: air currents begin to be heated, i.e., there is limited transformation of air into fire, as soon as some parts of the current encounter an internal source of heat, regardless of the route by which currents enter. The fire molecules now part of these spatially extended air currents will seek to leave the body by the fastest route possible. This, I suggest, is the route by which the relevant air currents entered, since heating occurs as soon as air molecules encounter some internal source of heat (even if it takes a critical mass of fire molecules to actually reverse the direction in which the current moves).

As noted earlier, Timaeus mentions only briefly the cooling function of respiration in his discussion of the respiratory fish trap (at 78e5) and does not incorporate into his discussion the lungs aside from noting that "branches" of the ἐγκύρτια (i.e., air currents that constitute the ἐγκύρτια) lead both into the belly alongside the windpipe (παρὰ τὰς ἀρτηρίας) and into the lung down along the windpipe (κατὰ τὰς ἀρτηρίας) (78c3–d1). For all that has been said here, however, these different aspects of respiration seem quite compatible. Indeed, I would argue that the cooling function supports the explanation of the change in direction of air currents proposed above. For the air currents that constitute the ἐγκύρτια are heated not just by the fire that cuts food in our belly, but already when entering the lungs, cooling down the heart as the seat of the spirited part of the soul in the process (cf. 78c3–d1). Seeing as the heart is located above the belly, partial heating of the air currents that are constitutive of the ἐγκύρτια would plausibly lead to some air molecules transforming into fire molecules further up the current relative to the heating that occurs upon air encountering the fire in our belly (at least at times in which the heart requires some serious cooling). If so, incorporating the cooling function of the lungs may actually help explain why air currents enter and leave by means of the same route, and thus the constant reversal of the direction in which the air currents are moving.

It may be helpful to note at this juncture that we can distinguish between the phenomenon of inhalation and exhalation on the one hand and the motion of the fish trap as a whole on the other. Inhalation and exhalation by means of the ἐγκύρτια are the movements of air and fire that we would intuitively think of as

breathing in and out. As far as these movements are concerned, the change in direction fits our everyday experience of breathing in and out. The motion of the fish trap's vessel through the pores of our body need not fall under the description of inhalation and exhalation strictly speaking.[28] One might thus describe the regular motion of the fish trap as follows. We inhale air currents that are heated inside our body, where this heating process involves air molecules transforming into fire molecules. These fire molecules, in turn, seek their cosmic like and thus leave the body, and so we exhale. Once outside the body, the current of hot air that we have just exhaled cools down as fire molecules transform back into air molecules. Exhaling this current pushes the air molecules that constitute the airy vessel of the fish trap through the pores of our trunk to the inside of our body. There, the air that constitutes the vessel is heated as some of its air molecules turn into fire molecules. These fire molecules, too, seek their cosmic like, and so the vessel's molecules move back outside through our porous flesh, in the process pushing up air through our mouth and nose, with the result that we inhale once more.

If this reconstruction is right, we may think of the fish trap's motion in terms of the following division of labour. The like-to-like motion of fire (including that of the fire molecules that result from the heating of air currents) explains the change in direction – that is, the switch from inhalation to exhalation back to inhalation and so on. It provides the impetus for each time the entire fish trap "moves around once." The principle of circular thrust explains what happens as a result of that impetus, i.e., how the motion that is driven by fire seeking its like plays out overall. Finally, the fact that the fish trap is a closed system in the material/constitutive sense developed above explains why the fish trap moves in a regular pattern over time. Of course, the fish trap's motion is not uniform, since its velocity keeps changing: the fish trap, considered as *one* entity, changes direction after each round, and stops moving for an instant each time it changes direction. But the fish trap moves *in a regular pattern*, and there is no reason to think that its average speed per "revolution" changes.

*

In light of the above reconstruction, consider once more the choice of analogy of the fish trap. The respiratory fish trap is a closed system in the sense that it is constituted out of (more or less) the same triangles throughout a person's life. Once the triangles grow weak, the chopping stops; and once the chopping stops,

28 This is arguably supported by 79c5–7, and by the phrasing of 79e7–9: τὸ δὲ τὰ αὐτὰ πάσχον καὶ τὰ αὐτὰ ἀνταποδιδὸν ἀεί, κύκλον οὕτω σαλευόμενον ἔνθα καὶ ἔνθα ἀπειργασμένον ὑπ' ἀμφοτέρων τὴν ἀναπνοὴν καὶ ἐκπνοὴν γίγνεσθαι παρέχεται. Here κύκλον … ἀπειργασμένον is in apposition to inhalation and exhalation (where τὴν ἀναπνοὴν καὶ ἐκπνοὴν cannot describe τὸ πάσχον κτλ., which is nominative).

replenishment stops.[29] Until then, what matters for purposes of bodily maintenance is the fire inside us moving through our belly and chopping up the plants we have eaten. Some of these fire molecules leave the body as part of hot currents of air, trying to reach their cosmic like – though, once outside and surrounded by air, they merely transform into air molecules instead as the air currents cool down. Happily, the fish trap's motion is such that hot air, and thus some amount of fire, leaving our body via one route coincides with cold air entering it via the other route, ensuring that our internal furnace is supplied with triangles that can form new fire molecules if need be. Arguably, there is thus a way in which the fire that cuts up food inside our belly may be considered as an analogue of fish: while the fish inside a fisherman's fish trap are kept alive by incoming streams of water until the fisherman comes to collect them, the fire that cuts up food in our belly is maintained by incoming currents of air (certainly the up and down motion of this fire is so maintained).

My final point about the fish trap *qua* analogy is that it supports my proposed reading of 77a–81e as an account of "the replenishing system." We can think of the respiratory fish trap as combining two different mechanisms: when we are concerned with the fish trap *qua* transit or conveyor mechanism, we are concerned with the movement of air currents (what we think of as respiration), and so what is relevant in that context is the fish trap insofar as it is airy. But when we are concerned with the fish trap *qua* chopping or driving mechanism, we are concerned with the movement of fire – and so we are interested in the fish trap insofar as it is fiery. Now, if Timaeus intended to give a theory of respiration and the respiratory system, the analogy of the fish trap would not be a great fit, seeing as it does not explicitly incorporate the lungs and their role in cooling down the heart (though, as I note above, the fish trap seems compatible with this cooling function, and indeed the cooling function would seem to fit quite well into the account of the fish trap's motion developed above). Worse yet, the fish trap involves parts of what we consider systems distinct from respiration, viz. parts of what we tend to think of as circulation and digestion. But the image of the fish trap succeeds in capturing the very parts and aspects of these systems that are relevant to bodily maintenance – in short, it captures the replenishing system.

3 The Project of *Timaeus* 77a–81e in Context

In the previous section, I developed a functional reading of the fish trap analogy and, in line with that reading, an account of the respiratory fish trap's motion. I

29 Indeed, once replenishment stops, respiration stops – or so Timaeus seems to suggest in the initial overview of the replenishing system (78c–79a, prior to the more in-depth account of the fish trap) when he says that respiration continues as long as the mortal animal "holds together" (78e1, following Zeyl's translation of συνεστήκῃ).

have also argued that, so understood, the choice of analogy itself supports reading *Tim*. 77a–81e as an explanation of bodily replenishment and maintenance. This section focuses on some of the wider implications of the account developed so far. I begin by laying out two interpretive advantages of my reading of the passage as a whole that also bring out ways in which it supports and illuminates the coherence of the reason-and-necessity explanatory framework as applied to the human body. I then consider the relevance of the passage to how we understand two more specific explanatory principles that recur both in the *Timaeus* and elsewhere, viz. like-to-like motion and circular thrust. Finally, I sketch some methodological considerations raised by my account in this connection.

The first interpretive advantage of reading *Tim*. 77a–81e as an account of bodily replenishment and maintenance is that it turns at least two alleged bugs into features. First, (a) there is no reason why Timaeus should integrate explicitly remarks he makes elsewhere in the dialogue about other aspects of respiration, circulation, and the organs involved in those processes, if these are not relevant to replenishment. Most prominently, at 70b–d Timaeus discusses the cooling function of respiration as an antidote to excessive heat generated in the heart *qua* seat of the spirited part of the soul, as well as the teleological structure and location of the lungs that enables such cooling: human lungs are bloodless, porous, and surround the heart "like padding" (70d3), allowing cold air and drink that enter the lungs to cool down the heart (70c5–d5). In our passage, Timaeus mentions the cooling function of respiration only once, when listing functions of respiration in general (78e5).[30] On the reading that I propose, 77a–81e is not concerned with the respiratory system (and other systems) or the process of respiration *as such*, but rather only insofar as any such system or process is relevant to bodily replenishment and maintenance. Of course, a complete account of respiration and the respiratory system would draw on all relevant passages, and if any inconsistencies between them were to arise, this would be a problem. But to the extent that the lungs' role in cooling the heart is not relevant to an account of replenishment and maintenance, we should not be surprised that Timaeus does not discuss it here – just as we should not be surprised that Timaeus mentions briefly the connection between the network of blood vessels and sensation or perception (*aisthēsis*) at 77e5–6, but does not go into any detail about the role of

30 For a related criticism that goes beyond the charge that Timaeus fails to incorporate key components of the respiratory system in an account of that very system, cf. *De Resp*. 5–6. There, Aristotle suggests that if the theory were correct, it should be universalizable to all animals on the grounds that the Timaean respiratory system is linked to "vital heat" or "internal warmth", something that is had by every animal (as Timaeus says at 79d1–2) – yet not all animals breathe. Aristotle's criticism does not seem to take into account the implicit Timaean distinction between internal heat that requires cooling (internal fire generated in the heart) and internal heat that does not require cooling (internal fire necessary for cutting food in the belly).

blood in the transmission of affections that eventuate in *aisthēsis*. (b) Since the project of the passage is not to develop a theory of respiration, Timaeus likewise has no reason to concern himself with voluntary deviations and exceptions to the regular pattern of respiration, such as holding one's breath. Galen criticizes the Timaean account on the grounds that it ignores voluntary control over respiration (*PHP* 8.8, 708M/712K ff.), but an account of holding one's breath would not help explain the regular, continuous pattern of inhalation and exhalation throughout our lives in the absence of voluntary, conscious engagement. It is this regular, continuous, non-intentional pattern, however, that is Timaeus' explanandum here, since that is what matters for bodily replenishment and maintenance.

Another advantage of the proposed reading is that the passage so understood displays a clear internal logic. At 77a, we learn that the fire and air in the environment around us continually attack and deplete our bodies. That is to say, the passage begins by explicitly framing the creation of plants in terms of reason working within constraints imposed by necessity, drawing our attention to the need for bodily maintenance: it is because of environmental depletion that the gods create plants for us as a temporary remedy, and this depletion occurs because humans necessarily (ἐξ ἀνάγκης) spend their life surrounded by air and fire that chip away at their bodies (77a1–3). Plants are akin to human nature (συγγενῆ, 77a4–5) and hence ideally suited to serve as our nourishment, allowing us to counteract depletion and loss of bodily matter to the environment.[31]

The process of designing and constructing a solution to environmental depletion is continued throughout the passage (cf. e.g., 77c6 ff., 78a6–b4), and it is against this backdrop that the remainder of the passage explains how exactly plant-based replenishment works.[32] First, 77c–78c lays out the material basis of the

31 See Johansen (2020) for helpful discussion of how we may think of both environmental depletion and nutrition as (partially) caused by the world soul insofar as it is the world soul's motion that is ultimately responsible for continued molecular changes inside the cosmos.

32 Contrast Pelavski (2014), who considers 77c–81b to be a unit about physiology following a unit about anatomy (73b–76e): "[o]nce the anatomy is completed, the account focuses on how the organs function, i.e., on physiology" (2014: 62). One problem with this suggestion is that the organs discussed in 73b–76e are not discussed in 77a–81e; only the belly and the marrow feature in any significant capacity. Contrast also Cornford, who, as mentioned earlier, takes 77c–81e to be unified by a problem of hydraulics, specifically the question of how blood can be distributed throughout the body (1937: 303). Cf. p. 306 (*ad* 77c–e): "The passage is most easily understood, not as a grossly inadequate account of the circulatory system, but rather as formulating the mechanical problem of hydraulics." On Cornford's reading, the account of the fish trap that follows in 77e ff. solves this mechanical problem. So understood, it is evidently less natural to take the section on plants as part of this discussion. Similarly, while the final sections focusing on digestion as well as growth, aging, and death are relevantly connected to the mechanical problem and its solution, they are not in and of themselves part of the same account.

replenishing system: blood vessels for distributing replacement matter, the belly, and the currents of air and fire that Timaeus likens to a fish trap. Timaeus then proceeds to explain the replenishing system itself. Replenishment takes the form of replacing material bits that were lost to the environment with new bits of the same kind, so to get from eating plants to repairing bodily damage, the plants must be cut up into appropriate, "new" material bits that are then distributed throughout the body via the bloodstream.[33] It is the motion of the respiratory fish trap, explained in detail in the central part of the passage (78c–80c), that brings this about (80d–81b). In giving an account of how the fish trap's regular motion comes about, Timaeus also explains why it continues throughout a person's life (78e1–2), invoking a principle of motion in a plenum that also explains certain other phenomena (79a5–80c8). When the account of replenishment comes to an end at 80d–81b, Timaeus returns to the key points made in the programmatic opening section on plants (77ab), viz. inevitable environmental depletion and the gods' creation of plants as nourishment to counteract that depletion.

For all that has been said up to this point, we should be able to replenish and hence maintain our bodies indefinitely, provided that we keep eating plants and do not interfere with our breathing. The final section (81c–81e) explains why the maintenance of human bodies is possible only for a finite amount of time. When the fish trap's constitutive triangles can no longer cut up plant matter, replenishment comes to an end while environmental depletion continues, resulting in old age and natural death (81d–e). In sum:

77a–c Depletion, the need for replenishment, and plants as the source of replenishment.

77c–78c The replenishing system's material basis (blood vessels, belly, respiratory fish trap).

78c–81b The replenishing system in action (the motion of the respiratory fish trap; principles underlying this motion; the fish trap's motion bringing about replenishment).[34]

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33 I here assume that a damaged body part at a certain level of complexity can be described in terms of the loss or perishing of its material constituents at a lower level of complexity, such that we can unproblematically think of "replenishing" as covering both repair and replacement (in the case of damage that is such as to be repaired or fixed by replacing lost material bits with new bits).

34 More specifically:

78c–79a: basic overview of the replenishing system in action.

79a–80c: more detailed explanation of the respiratory fish trap's motion and the principles underlying that motion.

80d–81b: more detailed explanation of the digestive and circulatory processes driven by the fish trap's motion.

81c–e Growth, maintenance, and natural death in terms of depletion and replenishment.

So understood, the passage is coherently structured. Not only does this reading allow us to see 77a–81e as a unified passage with a clear internal structure, it also makes good sense of the passage in context: after explaining the construction of the human body in light of certain material constraints (72c–76e), Timaeus turns to the *maintenance* of this body in 77a–81e, as well as the inevitable, gradual failure of such maintenance that results in aging and natural death. This final topic, in turn, gives Timaeus an ideal transition to his account of the body's unnatural disintegration through disease in 82a–86a.

Significantly, on the reading proposed here, the account of bodily maintenance in 77a–81e is a prime example of the workings of reason within the material constraints of necessity (precisely the domain that Timaeus identifies as the focus of the remainder of his speech at 68e–69b). The preceding section (72c–76e) illustrates the collaboration and compromise between reason and necessity in designing and constructing various body parts, most famously perhaps the human head (75a ff.). In our passage, this explanatory framework easily and informatively extends to the maintenance of the body. The teleological account of bodily maintenance in 77a–81e thus completes that of bodily design and construction in the preceding section.

Beyond its significance for the coherence of Timaeus' reason-and-necessity explanatory framework as applied to the human body, the replenishing system has noteworthy implications for our understanding of certain principles of motion, both as they figure in the *Timaeus* and insofar as the passage may or may not shed light on other ancient appeals to such principles. More specifically, the respiratory fish trap's motion matters for how we should think of like-to-like motion and circular thrust as general principles of motion in the Timaean cosmos.[35] The respiratory fish trap has been taken to illustrate a general principle of motion called *periōsis*, later termed *antiperistasis* by Aristotle.[36] Of course, the fish trap's motion does involve air currents pushing and being pushed around, and Timaeus does appear to have in mind a general principle of motion that may aptly be named *periōsis* or circular thrust (especially at 80a–c, sometimes labelled a "digression"

35 For discussion of like-to-like motion earlier in the *Timaeus*, see e.g., 58a–c and 63b–e.

36 Cf. e.g., Cornford (1937: 315–320), Berryman (2009: 77–9), Karfík (2012: 177), and Betegh (2020).

on circular thrust).[37] But it is not obvious that the text gives us enough for a theory of motion by *periōsis*. Indeed, it is not even clear whether the text gives us a fully general statement of the principle, of the sort that Timaeus elsewhere does not hesitate to give.[38]

The only possible candidate for a general statement of *periōsis* is at 80c3–6, where Timaeus once more denies the existence of the void, having just mentioned a few striking phenomena such as lightning and magnetic or electrostatic attraction:

> πάντων τούτων ὁλκὴ μὲν οὐκ ἔστιν οὐδενί ποτε, τὸ δὲ κενὸν εἶναι μηδὲν περιωθεῖν τε αὐτὰ ταῦτα εἰς ἄλληλα, τό τε διακρινόμενα καὶ συγκρινόμενα πρὸς τὴν αὐτῶν διαμειβόμενα ἕδραν ἕκαστα ἰέναι πάντα.
>
> Of all these, not a single one involves force of attraction; rather, [1] there is no void and these things shove themselves around (*periōthein*) into one another, and [2] they all go, [a] separating and combining, [b] each of them to their own place/abode, [c] exchanging [places] (80c2–6).

But quite aside from the (non-trivial) question about the scope of this claim, it is not obvious how the different kinds of motion – viz., [a] intertransformation, [b] like-to-like motion, and [c] circular thrust (or perhaps simply locomotion in a plenum) – relate to one another. Arguably, these lines raise more questions than they answer, such as whether or not different kinds of motion, and perhaps different "principles of motion," are reducible to a single one that can be stated or described in different ways (depending e.g., on the level of complexity of the relevant things in motion), and whether or not we should think of like-to-like motion as "force-like" or as a way of capturing cumulative passive affections (cf. 58a–c, where the relation between like-to-like motion and inter-transformation

37 Cf. Berryman's discussion of *antiperistasis* as one of four general approaches to explaining phenomena such as breathing and cupping instruments (the other three being an appeal to the void, taking the attraction of certain kinds of matter as primitive, and appealing to the continuity of matter) (2009: 75–8). Evidently, most of the phenomena Timaeus mentions here (incl. breathing) were often explained together, most frequently by appeal to either mutual replacement in a plenum or 'the power of the void'. This makes it easier to see why the so-called digression occurs here, and why Timaeus so explicitly postpones his explanation of the concordance of sounds at 67b–c. Notably, the word *periōsis* as the general term for such motion occurs only in Aristotle, who uses the term when talking about the theory of respiration in the *Timaeus* at *De Resp*. 472b6 (Ἡ δ᾽ ἐν τῷ Τιμαίῳ γεγραμμένη περίωσις…). Cf. Galen *PHP* 8.8, 708M/712K ff; Barker (2000: 89–90). Only three forms of the cognate verb occur in the passage (at 79c6, 79e2, and 79e6), and there is no lack of other verbs, like pushing *simpliciter* (ὠθεῖν) and driving around (περιελαύνειν), for example.

38 E.g., at 77e7–b1, where Timaeus says that one must first agree to the principle that smaller things contain larger things but not vice versa, and then appeals to that principle in order to explain the material components of the fish trap.

between different kinds of molecules seems similarly underdetermined). Even if these lines contain a general statement of *periōsis*, then, it would seem to be restricted to *periōsis* in the context of Timaean physics and cosmology, or so the possible link to molecular intertransformations might suggest. Aside from these difficult lines, the most general description of *periōsis* occurs at 79b–c (quoted above); but that description features breath as the subject, until "everything" is pushed "into the space *that breath left*" and "*follows breath* by entering that place and re-filling it" (79b1–c7). In brief, we do not have any clear, general statement or detailed illustration of the principle outside the context of the respiratory fish trap's motion, and that opens up the risk of building features specific to it into our general understanding of circular thrust.

As noted above, any account of the regular pattern in which the fish trap moves will include or appeal to (i) like-to-like motion (especially the like-to-like motion of fire), and (ii) some principle of circular thrust (understood, minimally, as a general principle of motion in a plenum by displacement).[39] On my reading, explaining this regularity also involves (iii) the fact that the fish trap is a closed system in the material/constitutive sense, which explains why the fish trap's motion stops once its material constituents break down. The particular kind of regularity exhibited by the fish trap's motion is a good example of why the fish trap is not ideally suited to illustrate circular thrust as a general principle of motion in a plenum. For this regularity depends on the fish trap being a constitutively closed system, a feature that distinguishes the fish trap's regular motion from other phenomena that appear in the so-called digression on circular thrust at 80a–c. Indeed, projectile motion, which Timaeus mentions at 80a1–2 and which is often considered a paradigm example of circular thrust, is quite different.[40] Unlike projectiles, the fish trap *remains* in motion and is not merely the extension of human action (as in the case of projectiles and cupping instruments). Similarly,

39 It is this regularity over time, I think, that commentators have in mind when they call the fish trap's motion 'automated' or 'mechanical'. Cornford, e.g., writes that Plato "attempts to show that respiration itself is maintained mechanically…" by invoking the "purely mechanical" principle of circular thrust (1937: 315). Karfík writes that "this device [viz. the fish trap] is working on purely mechanical lines" Karfík (2012: 178); similarly, Brisson (2001: 54): "L'appareil respiratoire, qui présente l'aspect d'une nasse […], donne lieu à une explication purement mécanique". See Berryman (2009: 9–20) for reasons why we might want to be cautious with this terminology.

40 In the extremely condensed account of the concord of musical sounds in 80a–b, the motion of sounds – motion that is supposed to be due to circular thrust – likewise lacks any such regularity. Developing an account of the concord of musical sounds at 80a–b is a project that none other than Andrew Barker has called "perhaps impossible" (though cf. Cornford (1937: 320–326), who proposes such an account). On 80ab–b5, Barker writes: "The general character of the process that Timaeus envisages is clear enough; but it would be hard – perhaps impossible – to provide a plausible and consistent analysis of its details" Barker (2000: 89).

while the motion induced by the use of cupping instruments is deservedly a standard example of applied pneumatics or hydraulics,[41] there is too much going on in the fish trap's motion for it to essentially amount to the solution of a problem of hydraulics, as Cornford thinks.

In light of this, then, there is good reason to be methodologically cautious when it comes to using the respiratory fish trap's motion as an example of *periōsis*. Isolating the precise contribution of this one principle (if it is a distinct principle) to the fish trap's overall motion is not exactly a straightforward task. Quite plausibly, that is just as it should be. After all, the fish trap's motion is the solution to a fairly complex problem: counteracting regular, continuous bodily depletion with equally regular, continuous bodily replenishment, to be maintained over an extended but most definitely finite period of time. Maintenance can occur without the conscious involvement of the human soul, allowing us to turn to other pursuits and take care of our souls, but it necessarily falls short of the self-sufficient metabolism of the cosmic body.[42] Though the Timaean account of bodily replenishment and maintenance does not provide everything that commentators have looked for in it, it nonetheless turns out to be unified, coherent, and well integrated with the dialogue's broader explanatory framework. Perhaps we should not have expected any less from Timaeus.

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41 Cf. Berryman (2009: 76 f.).

42 Karfík (2012) suggests an intriguing parallelism between the cosmic soul's *periodos* and the respiratory fish trap; for further development of this thought in the context of cosmic and human health, metabolism, and disease, see Betegh (2020). Cf. also Johansen (2020), pp. 125–130.

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