The role of efficient causation in Aristotle's philosophy: ensuring the continuity and coherence of the cosmos within a teleological framework

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Chapter 3: The Role of Efficient Causation in Sustaining Continuity and Coherence in Aristotle's Universe

According to the discussions in Chapter 2, although Aristotle attempts to utilize the final cause to provide an explanation for everything in the universe, the final cause appears to have a limited role in different fields of the universe, namely, cosmology, the motions of elements, meteorology and biology.

My contention is that Aristotle implicitly acknowledged the boundaries of final causation in providing a full explanation of the cosmos – testify the role of efficient causation to guarantee a unified explanation of the universe in terms of continuity and coherence. In fact, there are many cases in the universe that cannot be explained through a final cause but can be explained by an efficient cause;[172] moreover, the efficient cause more directly explains the chains of interaction between otherwise disconnected regions in the universe[173]. For instance, the disconnection between heavenly region and sublunary region and the lack of interaction between heavenly bodies.[174] Therefore, it is necessary to investigate how Aristotle's efficient cause contributes to a unified explanation of the universe – that is, the way in which it complements final causation in sustaining a comprehensive explanatory structure – and discuss how Aristotle's efficient cause helps to explain the cases which cannot be explained by final cause. Since even though many scholars have realized the limits of the contribution of the final cause to the unified explanation of the universe in Aristotle's works[175], they rarely paid attention to the achievement of the efficient cause to a unified explanation in

[172] For instance, a specific phenomenon in Aristotle, which could not be explained by the final cause, is the spontaneous generation of living things. Significantly, Aristotle employs efficient causal explanations to account for this phenomenon. (See detailed discussion in Chapter 2.4.3)

[173]Some commentators have criticized the disconnection between heavenly region and sublunary region with respect to Aristotle's theory of elements. See Solmsen (1960, 290), Freudenthal (2009, 239), Hankinson (2009, 84) and Falcon (2005, 87–88; 101–102).

[174] See detailed discussion in Chapter 3.

[175] See chapter 2.

Aristotle's thought.[176] In Aristotle's works, however, efficient causes directly explain the chains of interaction between different regions in the universe and play an important role to the unified explanation of the universe.

Thus, what I undertake to do in this chapter is to survey the contribution of the efficient cause to provide a unified explanation of the universe throughout the Aristotelian corpus of natural philosophical treatises. I divide the investigation of this chapter into four sections. Section 3.1 discusses the contribution of the efficient cause to a unified explanation in the field of cosmology. The starting point of the investigation is *Phys* VIII, where the Unmoved Mover operates as an efficient cause to unify all the changes and motions in the universe. Section 3.2 explores the contribution of efficient causes to a unified explanation in the motion of elements, including the chains of interaction between the four sublunary elements, and the chains of interaction between aether and the four sublunary elements. Section 3.3 explores how the efficient cause contributes to a unified explanation in the field of meteorology. Many modern scholars have criticized the disconnection between the celestial region and sublunary region in Aristotle's universe.[177] But in my interpretation, these two regions are directly and closely connected by efficient cause. The coherence of Aristotle's universe in the field of meteorology is guaranteed by the continuous efficient causal chains. Section 3.4 investigates the role of the efficient cause providing a unified explanation in the field of biology. The vital heat produced by the Sun is the efficient cause of the reproduction of living things in the sublunary world, which is different from the ordinary heat produced by the Sun, so it is necessary to investigate the efficient causal chains from the celestial realm to the sublunary realm.

[176] Some of the scholars who have studied the efficient cause in Aristotle discuss efficient cause in relation to other causes, e.g., Henry (2019), Scharle (2008b); Jack (2000); Code (1997) and Lewis (1988); while some of them focus on the clarification of Aristotle's notion of efficient cause itself, e.g., Tuozzo (2014); Huismann (2022), Schmaltz (2014) and Annas (1982), most of them explore the role of efficient cause in some specific fields, namely in physics and the generation of living things, e.g., Martin (2017b); Connell (2016), Code (1999) and Berti (2000).

[177] E.g., Freudenthal (2010, 239), Falcon (2005, 87–89) and Solmsen (1960, 290).

3.1 The Role of Efficient Causation in Achieving a Unified Explanation in Aristotle's Cosmology

Having examined the definition of Aristotle's efficient cause based on his *Metaphysics* and *Physics*, now I am in the position to investigate the role of efficient causation complementary to final causation in sustaining a comprehensive explanatory structure in the different fields of Aristotle's universe [178]. The first step is to examine the contribution of the efficient cause to a unified explanation in the field of cosmology. Following Aristotle's discussion, I treat *Phys* VIII as the starting point of my investigation, where Aristotle conceives of the first mover as the primary efficient cause of all the motions in the universe. As we have seen that the first mover is the starting point of all efficient causal chains in the universe, obviously in the field of cosmology the efficient cause derives its impulse of unity through causal chains from this starting point as well. Then turn to examine *Phys* VIII. 2, 5–6 and 10, and explore why the first mover must exist, as being the primary efficient cause of all the motions in the universe. Secondly, I shall discuss the efficient causal chains from the first mover to the heavenly bodies in the celestial realm, to survey whether the efficient causal chains are indeed continuous in this field.

3.1.1 The Role of Efficient Causation in *Physics*: The First Mover Unifies the Universe as an Efficient Cause

The eighth book of *Physics* sets the stage for the role of Aristotle's efficient cause in the field of cosmology. In this treatise, Aristotle attempts to prove the existence of the first mover, which is the primary efficient cause of all the motions in the universe, and thus to provide a starting point of all the efficient causal chains in the universe. So, I treat *Phys* VIII as the point of departure of my investigation as

[178] It has been argued in chapter 2.1.1 that the first mover unifies the universe as a final cause in Aristotle's *Meta*. The comparison between the role of the first mover in these two treatises will be discussed at the end of 2.1.1.

to how the efficient cause contributes to a unified explanation.

In order to investigate the role of the efficient cause in the field of cosmology, it is necessary to discuss how Aristotle comes out with the claim that the first mover is the primary efficient cause of all the motions in the universe. Before discussing Aristotle's arguments in detail, I prefer to show in brief the progression of his arguments. In the eighth book of *Phys*, Aristotle starts his investigation of the existence of the first mover which plays the role of the primary efficient cause by assuming that there always has been and always will be motion (*Phys* VIII.1–2), and claims that whatever is in motion is moved by something (*Phys* VIII.4). As a result, there should be continuous causal chains of motions in the universe. However, Aristotle then argues that it is impossible that every mover can be moved, otherwise the number of movers will be infinite, and the efficient causal chains will be infinite (*Phys* VIII.5), thus there must exist a first Unmoved Mover which is the primary efficient cause of all the motions (*Phys* VIII.6).

According to Aristotle's discussion, it is necessary to first examine why there has always been and always will be motion. I start my examination with Aristotle's critique of those who hold the view that there should be a beginning of motion (*Phys* VIII.1, 252a6–12). In Empedocles's view, there is a dual principle to be the beginning of motion, which can be understood as Love and Strife. Love and Strife alternately predominate and cause motion, while in the intermediate period of time there is a state of rest. Anaxagoras, however, believes in a single principle to be the beginning of motion, which he supposes to be Mind, and he claims that all things were together and at rest for an infinite period of time, and that subsequently Mind introduced motion and separated them. Concerning their views, Aristotle criticizes that it is impossible for there to be a beginning of motion, since that which holds by nature and is natural can never be disorderly, because nature is everywhere the cause of order (αἰτία πᾶσιν τάξεως), and there is no ratio in the relation of infinite to the infinite, whereas order always means ratio (*Phys* VIII.1, 252a14–16). Aristotle seems to be polemizing against Anaxagoras for assuming that in the cosmos things happen in a way that these things are no longer natural or a product of nature. In Aristotle's view, if a certain characteristic is natural, it either is so invariably or there is a ratio in the variation, for instance, fire is always naturally moving upwards. Thus, it is impossible that there is first a state of rest for an infinite time, and then motion is started at one moment. Aristotle suggests that—from the perspective that the universe is alternately at rest and in

motion, and therefore there is a certain order—Empedocles's view is better; however, Aristotle criticizes Empedocles for making mere assumptions and laying down unreasoned axioms: he should rather employ either inductive or demonstrative reasoning (*Phys* VIII.1, 252a22–25). Moreover, considering that the Love and Strife postulated are neither in themselves causes, nor is it of the essence of either that it should be so, the essence of the former being unity, while the essence of the latter is separation. Aristotle points out that Empedocles needs to adduce cases where such a state of things exists, and to go on to explain this alternate predominance (*Phys* VIII.1, 252a28–29). Empedocles points to the fact that among mankind, Love unites them while Strife separates them, hence according to the observed fact that this occurs in some cases, this leads to the hypothesis that it also happens in the universe. However, Aristotle thinks that Empedocles also needs to explain why each predominance lasts for an equal period of time (*Phys* VIII.1, 252a30–32). And Aristotle more generally observes that one should not assume that, for the fact that something always is or always happens this way, we have found an adequate first principle (*Phys* VIII.1, 252a33–34).

Compared with Empedocles's account, Aristotle thinks that Democritus's account comes closer to explaining why there always has been and always will be motion, since he reduces the explanation of nature to the fact that what happened in the past is the same as what is happening now; however, he does not think it is appropriate to seek for a principle to explain this 'always', so that although Democritus' theory is correct when applying to some individual cases, his theory is incorrect in treating it as universally applicable. Aristotle concludes by restating his view that 'there never was a time when there was not motion and never will be a time when there will not be motion' (*Phys* VIII.1, 252b5–6). In order to further support his view of the eternity and continuity of motion, Aristotle also responds to those who believe that motion is not eternal since there is a beginning of motion. Their view that there is a beginning of motion is based on the case of animate beings, since animals can produce a beginning of motion[179] (*Phys* VIII.2, 252b17–28). When there is no motion in animals, they are in rest, but when at some moment they are set in motion, they produce a beginning of motion in

[179] This is the case of self-motion in animals, see also *Phys* VIII.6, 259b5–15. On Aristotle's self-motion, see Gill (1994).

themselves without anything having set them in motion from outside[180], thus animals can move themselves. If this can occur in an animal, then it is possible that the same be true also of the universe as a whole, so it is possible that there is a beginning of motion. However, Aristotle criticizes the view that animals are capable to produce a beginning of motion, since there is always some part of the animal's body in motion, and the cause of the motion of this part is not the animal itself, but it may be its environment (*Phys* VIII.2, 253a12–15). More specifically, it may well be the case that many motions are produced in an animal's body by its environment, and some of these are set in motion the intellect or the appetite (ὄρεξις), and this again sets the whole animal in locomotion. Aristotle therefore argues that if in the case of the motion of an animal, it is impossible for an animal to completely produce a beginning of motion, the motion of an animal cannot be considered to be evidence that there is a universal beginning of motion. Therefore, Aristotle concludes that there never was a time when there was not motion, and never will be a time when there will not be motion, so it is a fact that motion is everlasting[181] and there always has been and always will be motion. Thus, it can be seen that Aristotle states and defends the doctrine that motion is eternal and continuous in the universe.[182]

It follows from this that all natural things in motion are moved by something. In Aristotle's view, the motion of all things is either natural or unnatural (*Phys* VIII.4, 255b12–14). On the one hand, for things that derive their motion from themselves, for instance, all animals, their motion is natural, since their motion is derived from themselves, and whenever the source of the motion of a thing is in the thing itself, the motion of this thing is natural. Aristotle here notes that the animal as a whole moves itself naturally, but the body of the animal may be in motion unnaturally as well as naturally, which depends upon the kind of motion that it may chance to be suffering and the kind of element of which it is composed (*Phys* VIII.4, 254b19–20). This explains why Aristotle considers the example mentioned earlier—where a part of an animal, set in motion by the environment, subsequently initiates the movement of the whole organism—a valid instance of

[180] But for inanimate things, they are always set in motion by something else from outside. (*Phys* VIII.2, 252b22)

[181] Solmsen (1960, 302) points out that Aristotle here for the first time (in relation to the chronology of the treatise assumed) establishes that motion is everlasting without introducing his own concept of the primary cause.

[182] See Blyth (2015, 23–25) on the everlasting motion in Aristotle.

'deriving one's motion from oneself.' More importantly, Aristotle distinguishes 'natural motion/change' from 'self-motion'. He identifies 'natural motion/change' as the motion of substantial bodies that are moved for the sake of something, and supposes that there are four basic kinds of natural motion/change: (1) locomotion—move/change with respect to place; (2) generation and corruption—move/change with respect to substance; (3) growth and diminution—move/change with respect to quantity; (4) alteration—change with respect to quality (e.g., form sickness to health). Every kind of motion/change is either one of these four, or it is not natural. (*Phys* III.1, 201a4–15).

On the other hand, Aristotle argues that the motion of things that derive their motion from something else is in some cases natural, in other things unnatural. For instance, I have discussed that the natural motion of fire is upward motion, while the natural motion of earth is downward motion[183], so the downward motion of fire is unnatural, while the upward motion of earth is unnatural. And the parts of animals can also move unnaturally when the character of their motion is abnormal. Aristotle notes that it is evident that, in unnatural motion, a thing that is in motion derives its motion from something else, since in these cases the motion is derived from something other than the thing itself (*Phys* VIII.4, 255b32–33). Moreover, as said above, all things which move naturally are also moved by something[184]. Aristotle demonstrates this through light things and heavy things, and explains that they are moved either by that which brought the thing into existence and made it light or heavy, or by that which released what was hindering and preventing it from moving. Thus, Aristotle thinks it is settled that all things that are in motion are moved by something (*Phys* VIII.4, 256a3).

Here Aristotle could have easily inferred that an efficient cause of motion is required from his definition of motion as a potentiality, which requires an agent to actualize it[185]. Moreover, in Aristotle's thought, what causes motion is relative to a cause of motion and the thing being moved, namely, the mover and the moved (*Phys* III.1, 200b31–32). The motion comes from the mover and occurs in the moved, and because whatever is in motion is moved by something, such things

[183] For the natural motions of element fire and earth, see chapter 2.3.1.

[184] Including those that are moved by themselves and those that are not moved by themselves.

[185] See Blyth (2015, 156). I also agree with his view (on the same page) that Aristotle's aim here is to argue as a physicist, not applying metaphysical notions, but appealing to concrete experience. In my mind, *Physics* VIII focuses on the investigation of a first mover in the sense of efficient cause.

will act and be acted upon by another in many ways: each of them will be capable at the same time of acting and of being acted upon, and thus, what causes motion as an agent can also be moved: when such a thing causes motion, it is itself also moved[186]. This allows Aristotle to analyze chains of moved movers in relation to their ultimate source and to conceive of the 'links' within these chains as acting upon the next simultaneously, thereby structuring continuous sequences of efficient causation throughout the universe.

However, although there are continuous efficient causal chains of motion in the universe and everything that is moved must be moved by something, this does not mean that Aristotle suggests these chains are infinite. The reason is that Aristotle supposes that it is impossible "for that through which a thing is moved to move it without being moved by that which imparts motion by its own agency; but if a thing imparts motion by its own agency, it is not necessary that there should be anything else with which it imparts motion, whereas if there is a different thing with which it imparts motion, there must be something that imparts motion not with something else but with itself, or else there will be an infinite series." Thus, Aristotle claims that if anything is a mover while being itself moved, the series must stop somewhere and not be infinite[187] (*Phys* VIII.5, 256a25–32). Aristotle brings forward the relationship of a hand and stick as an example: "if the stick moves something because of being moved by the hand, the hand moves the stick, and if something else moves with the hand, the hand also is moved by something different from itself. So, when motion by means of an instrument is at each stage caused by something different from the instrument, this must always be preceded by something else which imparts motion with itself."

This is enough to convince Aristotle that all chains of movers each causing another motion must originate with a first mover that operates as the primary and overall efficient cause of all the motions in the universe. Furthermore, the first mover must be unmoved. If a series of moved movers does not ultimately lead to an Unmoved Mover, it must terminate in a self-mover. However, a self-mover

[186] But Aristotle criticizes some people who suppose that every mover can be moved, since he claims that it is possible for a thing to cause motion, though it is itself incapable of being moved (*Phys* III.1, 201a22–27).

[187] This argument is closely related to *Phys* VII.1, 242a49–b52, where Aristotle argues that it is impossible that an infinite series of movers is shown to be equivalent to single infinite motion, so it is impossible if this is taken to constitute the evidence of a first Unmoved Mover. See also Ross (1956, 671–672), Wardy (1990, 331–332) and Johnson (2005, 252).

necessarily consists of a part that is itself moved. Thus, Aristotle establishes that the first mover is unmoved (*Phys* VIII.5, 256b13–24). Therefore, Aristotle concludes that 'there must necessarily be something eternal, whether one or many[188], that first imparts motion, and this first mover must be unmoved' (*Phys* VIII.6, 258b10–12).

Accordingly, in the eighth book of *Phys*, Aristotle makes it evident that there always has been and always will be motion, so the motion is eternal and everlasting. And since Aristotle proves that whatever is in motion is moved by something, it is apparent that the efficient causal chains of motion are continuous in the universe. But this does not mean that the chains of motion are infinite, otherwise the number of movers would be infinite. Thus, there must exist a first Unmoved Mover which is the primary efficient cause of all the motions, and the efficient causal chains which originally start from the first mover are continuous in the universe. By this point, it seems to me that the efficient cause can ensure a unified explanation, since the efficient causal chains of motions are continuous and everlasting in the universe.

Nevertheless, at first sight there may seem to be some tension between *Meta* XII and *Phys* VIII[189], since the first mover operates as a final cause in *Meta* while

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[188] For the number of the first movers, Aristotle thinks people should suppose there is one rather than many, and a finite rather than an infinite, since in things constituted by nature that which is finite and that which is better ought to be present rather than the reverse, and here it is sufficient to assume only one first Unmoved Mover, which is eternal and will be the principle of all motions in the universe (*Phys* VIII.6, 259a6–13).

[189] The exact connection between *Physs* VIII and *Meta* XII is a vexed issue. Blyth (2015, 358) claims that in *Phys* Aristotle argues as a physicist, not applying metaphysical notions as he does in *Meta*, but appealing to concrete experience. And according to Waterlow (1982, 172–173), Aristotle has an independent physical reason for inferring there must be a first mover in *Physics*, which is different from that in *Meta*. Ross (1956, 96) comments that Aristotle, in *Metaphysics* XII, describes the first mover as causing motion "as an object of desire" or "of love". According to Ross, this indicates that the first mover in *Metaphysics* is not a physical agent in the sense of producing motion through physical contact. Therefore, Ross suggests, the characterization of the first mover in *Metaphysics* is quite different from that in Physics, where the argument appears to proceed from physical considerations. Laks (2000, 243–245) also encounters this question, but he considers the tension as the ambiguity of Aristotle's argument. And Johnson (2005, 249–251) thinks perhaps the safest conclusion is that the Unmoved Mover of *Phys* VIII is not identical with that of *Meta* XII, but that there is no contradiction between the works, the differences being due to differences of perspective and procedure. It seems that many scholars have found a tension between these two texts, but my contention is that this 'tension' does not mean that Aristotle's argument is ambiguous, but means that Aristotle utilizes different causal explanations to guarantee the unified explanation of the universe in these two treatises, and I think this is also the evidence of Aristotle's attempt to utilize the combining descriptions of final and efficient causal explanations to guarantee the unified explanation of the universe.

it operates as an efficient cause in *Phys*. More precisely, in *Meta* XII, Aristotle discusses the first mover under the aspect of the final cause and claims that the Unmoved Mover pervades the universe as a final cause; while in *Phys* VIII, Aristotle investigates the Unmoved Mover in the sense of the efficient cause and supposes that the first mover is the primary and overall efficient cause of all the motions in the universe, so that the universe is unified by the continuous and everlasting efficient causal chains in the universe. More importantly, in my mind, the different role of the first mover in these two treatises can be viewed as evidence that a unified explanation of Aristotle's universe consists in combining final and efficient causal explanations[190].

3.1.2 The Continuous Efficient Causal Chains in the Cosmos: From the First Mover to the Heavenly Bodies

Having examined the existence of the first mover as the primary and overall efficient cause of all the motions in the universe, I go on to investigate the specific continuous efficient causal chains in the cosmos, in order to survey the role of efficient causes to a unified explanation in the cosmos.

As discussed above, there is a first mover that is unmoved and operates as the primary and overall efficient cause of all the motions in the universe, and thus the first mover must be the original source of the motions of heavenly bodies[191]. For the specific causal chains from the first mover, in *Phys* VIII.10, Aristotle first establishes the existence of the first everlasting moved body[192], which is the first body that is directly moved by the first mover. According to Aristotle, the first mover has no need to change along with that which it moves but it will be able to eternally cause motion, and this motion alone is regular since the first mover is

[190] For the combined descriptions of final and efficient causal explanation in a unified explanation of the universe, see chapter 4.

[191] According to the discussion above, I think it is clear that the first mover is somehow prior and operates as the efficient cause of all the heavenly bodies – even though Aristotle does not say so explicitly in *Physics*. Moreover, in *Metaphysics*, Aristotle clearly claims that the first mover is the efficient cause of the motions of heavenly bodies (Meta XII.8). On the first mover as the efficient cause of the motions of heavenly bodies in Aristotle, see also Apostle (1980, 324–325).

[192] In *Metaphysics*, Aristotle names 'the first everlasting moved body' as 'first moved body', or the 'the first heaven'.

never subject to any change. Aristotle says that in order that the motion may continue to be of the same character, the moved must not be subject to change in relation to it.

> So, it must occupy either the center or the circumference, since these are the principles. But the things nearest the mover are those whose motion is quickest, and in this case, it is the motion of the circumference that is the quickest: therefore the mover occupies the circumference.
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> *Phys* VIII.10, 267b5–8 (trans. R. P. Hardie and R. K. Gaye)

In this passage, Aristotle establishes the location and character of the first moved body. By supposing that this mover should have no need to change along with that which it moves but will be able to cause motion all the time, and this motion alone is regular since the mover is never subject to any change, Aristotle posits that the motion in the universe must originate either from the center or from the circumference of the universe. Then he claims that the motion which is directly imparted by the first mover must be the fastest of all motions, since the impetus must die away in the process of transmission. And because of his astronomical observation that the motion of the circumference is the quickest, Aristotle concludes that all the motions in the universe are transmitted from the first moved body, which is the first body that is moved by the first mover and is in the outer sphere of the universe[193]. Moreover, given the fact that the first mover acts directly on the first moved body, it seems that the first mover should be outside the circumference of the universe. By this point, it is plain that the first mover directly acts on the first moved body which occupies the circumference of the universe. However, according to Aristotle, there is a difficulty in supposing it to be possible for anything that is in motion to cause motion continuously and not merely in the way in which it is caused by something repeatedly pushing (*Phys* VIII.10, 267b10–11), since in the latter case, the continuity of motions amounts to no more than successiveness. But such a mover must either itself continue to push or pull or perform both these actions, otherwise the action must be taken by something

[193] Aristotle attempts to provide something concrete for this generalization by showing how heavenly bodies, especially the Sun, produce meteorological phenomena through their motion, forming the living things in the sublunary world, giving sublunary events their general shape and character though the rhythm of the day and night, sowing and harvesting. See also Ross (1956, 95–96) and chapter 3.4.

else and be passed on from one mover to another. It seems that in either case the motion cannot be a single motion, but merely a continuous series of motions. Aristotle also demonstrates the case of things thrown to explain the continuity of motions, since the air, which is divisible, is a mover because of the fact that different parts of the air are moved one after another (*Phys* VIII.10, 267b14–15). Therefore, the only continuous motion is the motion which is caused by the first mover, since it remains always changeless, and therefore its relation to that which it moves remains also changeless and continuous[194]. So, it can be seen that the efficient causal chains of motions, which originate from the first mover, are also continuous and everlasting.

Given that the first mover directly acts on the first moved body which occupies the outer sphere of the universe, to examine the specific efficient causal chains in the universe, it is necessary to clarify the efficient causal chains from the first moved body to other heavenly bodies. Although there is no argument about the interaction between the first moved body and other heavenly bodies in *Phys*, we can find some relevant arguments in *Meta*[195]. In this treatise, Aristotle again emphasizes that the first mover is unmoved and operates it as the primary efficient cause of all the motions in the universe, and he explicitly says that the first mover is the efficient cause[196] of the motions of all heavenly bodies whose motion is also eternal[197] :

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[194] Graham (1999, 118–120) criticizes that Aristotle's supposition that there must be a first mover to cause everlasting movements in the world does not really support the claim that the first moved body is everlasting, only showing that it is intermediary, and thus Graham claims it is wrong that 'everlasting' must be supplied as an attribute of the first moved body, following the description of that body in the conclusion, since what is moved will only normally be moved as long as the mover or in contact. In my view, according to Aristotle it is clear that the first moved body is everlasting. On the one hand, the first moved body belongs to heavenly bodies and Aristotle supposes that all the heavenly bodies naturally do everlasting circular motion (since the heavenly bodies are made of aether which naturally do circular motion (for detailed discussions, see chapter 2.3.2)), so the motion of the first moved body is everlasting. (It should be noted that the first moved body must be moved by the first mover even if the motion of the first moved body is everlasting.) On the other hand, Aristotle says that the efficient causal chains of motions which originates from the first mover must be continuous and everlasting (*Phys* VIII.10, 267b9–17), and therefore the motion of the first moved body ought to be everlasting to ensure the continuity of the efficient causal chains in the universe. As a result, the motion of the first moved body must be everlasting.

[195] See note 198.

[196] Aristotle refers to 'efficient' causes many times ('that from which the origin of the motion comes from') in *Metaphysics* (e.g., VII.17, 1041a32–33; XII.4, 1070b34–35; XII.5 1071b7–8). The first mover, being unmoved, produces the primary eternal and single movement (*Meta* XII.8, 1073a26–28). Therefore, the first mover must be the efficient cause of the motions of all the heavenly bodies.

[197] The heavenly bodies, which naturally move in a circle, are eternal and everlasting. (See *Physics*

> The first principle or primary being is not movable either in itself or accidentally, but produces the primary eternal and single movement. And since that which is moved must be moved by something, and the first mover must be in itself unmovable.
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> *Meta* XII.8, 1073a26–28 (trans. W. D. Ross)

Thus, the motion of each heavenly body must be caused by the first mover, and the first mover is eternal and prior to heavenly bodies, since movers are prior to the moved. For the efficient causal chains which originate from the first mover to the heavenly bodies, Aristotle assumes that one of the heavenly bodies is first and another second, and then another the third (*Meta* XII.8, 1073b17–19). So, the efficient causal chain seems to be: the first mover, first moved body (first heaven) which is moved by the first mover, the second moved body which is moved by the first moved body, and so on. It can be seen that such efficient causal chains, originating in the Unmoved Mover, are continuous and everlasting in the cosmos.

My contention, then, is that Aristotle's efficient cause is capable of guaranteeing a unified explanation in the field of cosmology, since there exist specific continuous and everlasting efficient causal chains in the cosmos, which originate from the first mover to the first moved body (first heaven), and then to other heavenly bodies, thus the efficient cause guarantees a good unified explanation of the universe in the field of cosmology.

3.2 The Role of Efficient Causation in Achieving a Unified Explanation in Aristotle's Elements

Having examined how the efficient cause contributes to a unified explanation in the field of cosmology, I now turn to survey the role of the efficient cause in the field of the motions of elements, in order to make it clear whether the efficient cause can ensure a unified explanation in this field. Aristotle announces five

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elements in the universe: the celestial element (aether) which naturally does circular motion; and the sublunary elements (earth, water, air and fire) which naturally do have rectilinear motion (*DC* I.2, 268b14–269a9). However, some scholars argue that there is a gap between the celestial realm and sublunary realm with respect to the fact that aether is eternal and imperishable, and thus has no interaction with the other four elements in the sublunary world. Therefore, in order to respond to these criticisms, it is necessary to explore whether there are continuous efficient causal chains between these five elements in Aristotle's project. Therefore, I divide my investigation of this section into two parts: the efficient causal chains between the celestial element (aether) and the four sublunary elements, and the role of efficient cause in the motions of the four sublunary elements.

3.2.1 The Continuous Efficient Causal Chains from the Celestial Element to the Four Sublunary Elements

Many scholars believe that the introduction of aether is Aristotle's great innovation within the elemental theory.[198] Other commentators have criticized Aristotle's introduction of the celestial element of aether,[199] since this would lead to a disconnection between the celestial region and sublunary region.[200] These

[198] For example, Solmsen (1960, 289) points out that Aristotle's aether endows the heavenly bodies with physical bodies, and therefore non-physical agents are again eliminated from the cosmos. Similarly, Longrigg (1975, 213) supposes that the innovation of aether enables Aristotle to abolish the psychophysical dualism of Plato and brings the heavens within the sphere of physical world. In my mind, Aristotle's innovation of aether brings the celestial world within the sphere of the physical world, and therefore brings the celestial world within the sphere of efficient causal explanation, since efficient causal explanation is sufficient to be applied to explain the physical world.

[199] For the reason why Aristotle supposes the existence of aether as the element of heavenly bodies, see note 111.

[200] Solmsen (1960, 299) comments that aether is quality-less and impassive, and hence, in principle, a stranger to generation and corruption, thus making the celestial world separate from the sublunary world. While Falcon (2005, 87–88; 101–102) thinks that Aristotle's celestial matter creates an important discontinuity between the celestial world and sublunary world, since aether is distinct from the ultimate material principles out of which everything in the sublunary world is constituted. Freudenthal (2009, 239) criticizes that considering the advantage of Aristotle's theory of matter alone, the sublunary world is now a closed system whose functioning depended solely on the laws of physics bearing on the bodies constituted of the four sublunary elements. However, although Hankinson (2009, 84) thinks that Aristotle is not (as is sometimes claimed) committed to supposing that there must be an individual element in the celestial world which is isolated from the other four

commentators apparently assume that aether separates the celestial sphere from the sublunary sphere, since there is no connection or interaction between aether and the four sublunary elements. So now it is questionable whether the efficient cause can guarantee a unified explanation in the field of elements, in other words, whether there are continuous efficient causal chains between aether and the four sublunary elements. But in my view, it should be noted that Aristotle does refer to interactions between aether and the four sublunary elements. In fact, throughout the Aristotelian corpus of natural philosophical treatises there are passages[201] that offer sufficient evidence for interaction between aether and the four sublunary elements. In what follows, I will focus on investigating these passages.

In *Meteor* I.3, 340b6–14, the circular motion of aether[202] is thought to be the efficient cause of the motions of sublunary elements, since Aristotle clearly says: 'Now the circular motion of the first element and of the bodies it contains dissolves, and inflames by its motion, whatever part of the lower world is nearest to it, and so generates heat'. The element of aether that constitutes the heavenly region exerts influence especially on the sublunary elements fire and air moving towards the upper region of the sublunary sphere, and thus closest to the celestial sphere surrounding the Earth[203]. The circular motion of aether has the power of dissolving and inflaming; it is capable of generating heat in whatever part of the sublunary realm which is nearest to the celestial realm. It is clear that there are interactions between aether and the four sublunary elements, since the heat, which is an important source of generation and corruption of the sublunary world[204], is generated by inflammation through the circular motion of aether.

Then, in *Meteor* I.3, 341a1–4, Aristotle shows the interaction between the aether and the sublunary element fire and air. The circular motion of 'the heaven', which consists of the element aether, carries the air with it and causes the circular motion of air, and then 'fire is being continuous with the upper element, and air

elements, he does not investigate the interaction between aether and the other four elements.

[201] See *Meteor* I.3, 340b6–14; *Meteor* I.3, 341a1–4; and *Meteor* I.3, 341b18–24; *GC* I.3, 318a1–6; *Cael* I.2, 339a23–33.

[202] For the natural circular motion of aether, see chapter 2.3.2.

[203] For better distinction, I prefer to use 'Earth' to show the planet Earth, while use 'earth' to express the element earth. In this way, I also choose to use 'Sun' to show the planet Sun, and use 'Moon' to show the planet Moon.

[204] For the role of heat as an efficient cause to the generation and corruption in sublunary, see chapter 3.4.1.

with fire'. Aristotle further supposes that this is also the efficient reason why air is not condensed into water. It thus becomes clear that the motion of aether functions as the efficient cause of the motions of air and fire, with the efficient causal chains linking aether to fire and air being continuous.

Next, in *Meteor* I.3, 341b18–24, Aristotle clearly indicates the interaction between aether and fire, since fire is ignited by the circular motion of aether owing to the fact that fire is part of the sublunary world which is the nearest to the heavenly bodies[205]. The specific interaction of aether and fire, then, is the starting point of the continuous efficient causal chains between aether and the sublunary elements.

Moreover, in *GC* I.3, 318a1–6, Aristotle emphasizes that the first mover and the heavenly bodies, which are always being moved by the first mover,[206] are the efficient causes of all the generations and corruptions in the sublunary world. Given that all generations and corruptions in the sublunary world are based on the interactions of these four elements, thus the heavenly bodies, which consist of aether, are thought to be the efficient cause of all the motions of these four elements. And similarly, in *DC* I.2, 339a23–33[207], the continuity between the celestial world and sublunary world is guaranteed by the fact that all motions in the sublunary world originate from the celestial world. The element of celestial bodies is eternal and complete, while the elements in the sublunary world, such as fire, receive their power of motion from the eternally moving bodies, thus there are continuous efficient causal chains between aether and the other four elements. Therefore, it seems that Aristotle holds that there is contact between aether and the elements in the sublunary world, since he makes explicit that the terrestrial elements are not self-sufficient and obviously aether directly acts on the sublunary elements by its circular motion.

However, Pearson comments that there seems to be an inconsistency in Aristotle's views about these events since Aristotle sometimes speaks of fire at the periphery of the sublunary region being ignited by the rotation of the lunar sphere,

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[205] For the reason why fire is nearest to heavenly bodies, see chapter 2.3.1 on the determinate place of fire.

[206] See also *Phys* VIII.6, 258b10f. For detailed discussions on the continuous efficient causal chains from the first mover to the motions of heavenly bodies, also see chapter 3.2.2.

[207] Scharle (2005, 156–157) has also discussed *DC* I.2, 339a23–33 and claims it shows the motions of sublunary elements are of necessity continuous with the upper motions.

but sometimes attributes such phenomena to dry exhalation, which is distinct from fire[208]. However, my contention is that, although in Aristotle's work there may be inconsistencies in his presentation of the interactions between aether and the terrestrial elements, these can merely be considered as different hypotheses about possible ways of contact, and do not affect the view that aether is capable of acting upon the terrestrial elements. Indeed, what Aristotle truly wants to express in these cases is the continuity between the motion of aether and the motion of four sublunary elements. Moreover, in Aristotle's thought, the dry exhalation[209] is also caused by the heat produced by the Sun, and since the Sun is made of aether, thus the dry exhalation in the sublunary world is also caused by aether. Therefore, both of these 'inconsistent views', can be resolved if we consider that fire is ignited by the motion of aether.

Accordingly, it seems to me that Aristotle's supposition of the existence of aether does not involve a disconnection between the celestial region and sublunary region, since Aristotle considers the circular motion of aether to be the efficient cause of the motions of four sublunary elements – which evidently implies interactions between aether and the sublunary elements. Therefore, with the role of Aristotle's efficient cause, there are continuous efficient causal chains between the celestial element (aether) and the four sublunary elements, and thus the celestial region and sublunary region are not disconnected.

3.2.2 The Efficient Causal Chains Between the Motions of the Four Elements in the Sublunary World

According to the discussion above, the efficient causal chains are continuous between aether in the celestial world and the other four elements in the sublunary world, so it seems that the efficient cause can ensure a unified explanation between

[208] In *Meteor* I.3, 341a29–36, Aristotle suggests that the elemental fire surrounding the air is often scattered by the motion of the Sun and driven downwards to Earth in spite of itself; while in *Meteor* I.4, 341b22–342a8, Aristotle says that when lots of dry exhalation is churned back to Earth by the heavenly motions, the heat in the upper layer should cool or moisten before it falls. For this inconsistency, which is pointed out by Pearson, see Gill (2010, 145). Moreover, here Gill also mentions another inconsistent view in Aristotle: if Aristotle takes fire's own place to be the extremity of the universe, the potency of fire to be in its place is never actualized.

[209] For the detailed discussions of the dry exhalation, see chapter 3.4.1.

aether and the other four elements. Now it is necessary to move on to examine the role of efficient causes in the motion of the four elements in the sublunary world, and to investigate the efficient causal chains between these four sublunary elements, namely, earth, water, air and fire.

Many of Aristotle's works discuss the behavior of these four elements, but most of his treatises investigate the interaction of these four elements in the process of forming compound bodies or in their own mutual transformations[210]. Given the fact that the sublunary world is made up from these four elements, many of the interactions of these four elements are part of phenomena happening in the field of meteorology[211] and biology[212]. In this section, however, I will focus on investigating the efficient causal chains in respect to the field of elements as such. Thus, it is necessary to explore the treatise *On Generation and Corruption*, where Aristotle utilizes the efficient cause to explain chains of interaction between these four elements in his analysis of the phenomena of generation and corruption in the sublunary world.

In *On Generation and Corruption*, Aristotle undertakes to describe the behavior of the four elements and explores the interactions of the four elements with respect to the formation of compound bodies and the circle of elemental mutual transformations. Before examining the efficient causal chains of interaction between these four elements in the generations and corruptions in the sublunary world, he emphasizes again that the first mover and the heavenly bodies, always being moved by the first mover,[213] are the efficient causes of all the generations and corruptions in the sublunary world (*GC* I.3, 318a1–6). Given that all generations and corruptions in the sublunary world are based on the interactions of these four elements, thus the first mover and the heavenly bodies are thought to be the efficient cause of all the motions of these four elements. Moreover, Aristotle claims that the generations and corruptions in the sublunary world happen everlastingly and continuously (*GC* I.3, 318a11–13)[214], and in order

[210] See also Gill (2010, 139–140; 2014, 343).

[211] For the efficient causal chains in the field of meteorology, see chapter 3.4.

[212] For the efficient causal chains in the field of biology, see chapter 3.5.

[213] See also *Phys* VIII.6, 258b10f. For the detailed discussions about the continuous efficient causal chains from the first mover to the motions of heavenly bodies, also see chapter 3.2.2.

[214] Here Aristotle claims that the generations and corruptions in the sublunary world happen continuously, and since generation and corruption are caused by the interaction of these four elements, thus it seems that the efficient causal chains in the four elements must be continuous.

to explain the continuity of these generations and corruptions, he focuses on examining the interactions of these four sublunary elements.

The four sublunary elements must be reciprocally active and susceptible, since they combine and are transformed into one another. Aristotle supposes four kinds of active or passive properties of these four elements, namely, hotness, coldness, wetness and dryness (*GC* II.2, 329b22–39). These four basic properties are utilized by Aristotle to explain the interactions between the elements. Hotness and coldness are active properties, while dryness and wetness are passive properties: the properties of hotness and coldness imply the power to act, while wetness and dryness imply susceptibility. Hotness is capable of associating things of the same kind while coldness is capable of bringing together homogeneous and heterogeneous things alike. And wetness is that which, being readily adaptable in shape, is not determinable by any limit of its own; while dryness is that which is readily determinable by its own limit, but not readily adaptable. These four properties are incorporated by Aristotle into an account of the process of the interaction of the elements.

In Aristotle's view, each element has two such distinguished properties. He ascribes to each of the elements' binary combinations of opposites: for earth is cold and dry, while water is cold and wet; and air is hot and wet, whereas fire is hot and dry (*GC* II.2, 330a1–330b8). The four elements interact with one another in the sublunary world because of these four properties. Aristotle argues that in the generation and corruption of the sublunary realm, opposites need to be allowed to function as independent principles, because it is obviously awkward to attach both of the opposites to one element as qualities. Moreover, in spite of the fact that this coupling of elements and opposites seems reasonable, since it is naturally plausible to ascribe wetness rather than coldness to water, it reflects Aristotle's thought about the interrelationship of the four elements with binary relations of opposites. If Aristotle considers the property of water to be wetness, he would distribute the properties of coldness and dryness between air and earth, since it is obvious that hotness is the property of fire. However, since the air is obviously hot and wet[215], its basic properties may be neither cold nor dry. In this regard, it is necessary to characterize water as cold. It can be seen that different elements have different properties, and these four elements interact with one another in the

[215] Aristotle supposes the air is hot and wet since he considers air as a sort of vapor (see *GC* II.3, 330b3–4).

sublunary world in virtue of their different properties. Now it is obvious that these four elements interact with each other in the composition of compound bodies and in their own transformations of the sublunary world, which are based on their four properties[216]. The interactions of these four elements are continuous and will never stop in the sublunary world; therefore, the generations and corruption are continuous and the existence of natural things in the sublunary is guaranteed. The continuous efficient causal chains thus exist in the chains of interaction between these four sublunary elements.

Furthermore, Aristotle observes that the transformation of these four elements seems to resemble a circular motion[217] (*GC* II.10, 337a1–10). For when water is transformed into air, air into fire, and the fire back to water, this generation has completed the circle, since it is back again at the beginning. It seems that the circle of transformations of the four elements is continuous and everlasting, just as the circular motion of the heavenly bodies is continuous and everlasting. Therefore, by imitating the circular motion of the heavenly bodies, the chains of transformations of the four elements are also continuous.

Accordingly, the four elements interact with one another in the sublunary world because of their different properties, and their interactions must be continuous and everlasting. Aristotle's utilization of efficient causes directly explains chains of interaction between the four elements in the sublunary world. With the role of efficient cause, there are continuous efficient causal chains between these four elements, thus the sublunary world is unified by the efficient cause in the field of elements. Moreover, considering that the circular motion of aether is the efficient cause of the motions of four sublunary elements and thus evidently initiates the interactions between aether and the sublunary elements, there are continuous efficient causal chains between the celestial element (aether) and the four sublunary elements. Therefore, with the role of efficient cause, there are continuous efficient causal chains among the five elements in the universe, and thus Aristotle's efficient cause ensures a unified explanation in the field of

[216] For the specific meteorological phenomena of rainfall, which are based on the interactions of sublunary elements, see chapter 2.4 and 3.4.

[217] Johnson (2005, 151) ascribes Aristotle's arguments that the transformation of these four elements into each other seems to resemble the circular motion to his explanation of the final cause. I tend to believe, however, that this is also Aristotle's utilization of efficient cause, since Aristotle here wants to show that the interactions of elements in their transformation form a circle, and therefore Aristotle says that their interactions are continuous by imitating circular motion (*GC* II.10, 337a9).

elements.

3.3 The Role of Efficient Causation in Achieving a Unified Explanation in Aristotle's Meteorology

Having examined the role of the efficient cause in a unified explanation in the field of the motions of the elements, now I move on to investigate the role of the efficient cause in the explanation of Aristotle's universe in the field of meteorology. As I have discussed in Chapter 2.4, Aristotle's final cause cannot be applied to the field of meteorology and is not capable of ensuring a unified explanation in this field, so in this section, I will focus on examining the role of the efficient cause and try to answer the question of whether there are continuous efficient causal chains in this field.

Aristotle has investigated various meteorological phenomena between the upper and lower realms of the universe with reference to the matter and sources of motions. The meteorological phenomena happen both (1) as a result of the four sublunary elements (earth, water, air and fire) being the cause of 'the events - in matter' – which seems to express that these four elements are not only the material causes of meteorological phenomena[218] (or more broadly, all sublunary events), but also 'subjects being affected' (*Meteor* I.2, 339a28–29), and (2) as a result of the eternally moving bodies as 'the cause whence the motion originates'[219] (*Meteor* I.2, 339a30–31). Thus, Aristotle's efficient cause plays an important role in meteorological phenomena between the celestial sphere and sublunary sphere. In this respect, I divide my investigation of this section into two parts. First, the important role of the Sun needs to be discussed. The Sun acts as an efficient cause to generation and corruption in the sublunary world. Secondly, I will examine the continuous efficient causal chains between the celestial world and sublunary

[218] According to the original text, it is 'the events in this world'; but according to the context, it should be 'all sublunary events'; however, based on the full book of *Meteorology*, Aristotle is mainly talking about the meteorological events.

[219] 'The cause whence the motion originates' is the efficient cause. For the definition of Aristotle's efficient cause, see chapter 3.1.

world in the field of meteorology.

3.3.1 The Sun Operates as an Efficient Cause to Generation and Corruption in the Sublunary Word

In Aristotle's field of meteorology, the Sun is the most important heavenly body to the sublunary world, since Aristotle realizes that the sublunary world cannot be self-sufficient, taking into account that the Sun warms it. In this section, I will focus on examining the role of the Sun which acts as an efficient cause to generation and corruption in the sublunary world. It is clear that Aristotle does not consider the Sun to be hot itself[220]; in order to explain how the Sun generates heat, Aristotle proposes two kinds of explanations[221].

In his first explanation (*Meteor* I.3, 341a19–28), Aristotle supposes that the motion of the Sun in the celestial sphere—being both rapid and near— is sufficient to account for the origin of heat; the Sun produces heat by inflaming the air. According to Aristotle, the analogy of terrestrial phenomena makes it reasonable that more heat should be generated in the presence of the Sun, since here, it is the air that is nearest to an object in rapid motion which is heated most. So, it is the nearest air that is most inflamed by the motion of the Sun, and this is one reason why heat reaches the terrestrial world. As the reason why heat reaches our world, Aristotle brings forward (*Meteor* I.3, 341a29–36) that the elemental fire surrounding the air is often scattered by the motion of the heavens and driven downwards to Earth in spite of itself. Aristotle further indicates that the phenomena of shooting-stars also suffice to prove that the celestial world is not hot and fiery, since they do not occur in the celestial world but in the sublunary world[222]. However, the more and faster a thing moves, the more likely it is to catch fire, and this is the reason why shooting-stars occur. Moreover, Aristotle notes that

[220] Aristotle denies that the heavenly bodies are themselves naturally hot. (See *Meteor* I.3, 341a14–18).

[221] The first explanation is discussed in *Meteorology*, while the second explanation is discussed in *DC*. It should be noted that Aristotle is just thinking about two kinds of possibilities to explain how the Sun generates heat without talking about which one is the best, or which one is right.

[222] Aristotle then posits that the phenomenon of shooting-stars which happens in the sublunary world is due to the combustion of the exhalation (*Meteor* I.4, 342a16–20).

the Sun is white and not fiery.

The second explanation[223] is proposed in *DC*, where Aristotle suggests that the Sun produces heat by the friction between it and the air in the sublunary world (*DC* II.7, 289a2532). Aristotle here utilizes the example of missiles to explain this explanation. Missiles moving are themselves fired so strongly that leaden balls are melted, and if they are fired, the surrounding air must be similarly affected. Now while the missiles are heated in virtue of their motion in air, which is turned into fire by the agitation produced by their movement, the heavenly bodies are carried on a moving sphere. Therefore, they do not catch fire themselves, however, the air under the sphere of the rotating object must be heated by its motion, especially in the part where the Sun is attached to it. Thus, Aristotle claims that warmth increases as the Sun gets nearer or higher or overhead. Regarding the second explanation, I concur with Wilson's assessment that certain difficulties arise in interpreting Aristotle's account; however, I disagree with his proposed solution. In *DC* IV.4–6, Aristotle appears to suggest that elemental fire does not exist in the heavenly realms except for the fire generated by air and sustained through the friction of the celestial bodies. This interpretation seems problematic, as it conflicts with Aristotle's elemental theory, according to which fire and air are independent elements rather than derivative phenomena. Conversely, if the heavenly sphere itself contained fire, this too would contradict Aristotle's framework, as Aristotle explicitly states that the heavenly sphere is neither hot nor fiery. To resolve these difficulties, Wilson proposes that Aristotle conceptualizes air as a form of smoke, which he equates with elemental fire. He further suggests that air transforms into fire through friction, arguing that, while Aristotle does not explicitly refer to smoke in this context, he elsewhere describes smoke as capable of combustion, thus linking it to the properties of fire. However, I find this interpretation unconvincing. Aristotle never refers to smoke in his discussions of the Sun's production of heat, nor does he suggest that heat generation in the celestial realm involves any transformation of air into fire. To infer such a conclusion solely on the basis of one shared property—namely, that both air and

[223] This description suggests that elemental air is transformed into elemental fire and that friction is the cause of the heat associated with that region, So, in the case of missiles moving through air, the surrounding air becomes fire. And it seems to be a modification of Anaxagoras' view that the stars shine because of the resistance and breaking round of the aether (λάμπειν ἀντερείσει καὶ περικλάσει τοῦ αἰθέρος), For the comparison between Aristotle and Anaxagoras on the generation of heat, see Wilson (2013, 57–49) and Anaxagoras A 12, II.9, 34–35 DK.

smoke can burn—seems tenuous and speculative. In my view, Aristotle's purpose in offering these two explanations is not primarily to resolve conceptual difficulties but to illustrate the efficient causal process underlying the production of heat. His argument aims to demonstrate that the motion of the heavenly bodies serves as the efficient cause of generation and corruption in the sublunary world—a topic I will examine in detail in Chapter 3.3.2. Thus, the question of whether there are interpretative difficulties in his account is secondary to his primary concern, which is to establish the causal role of celestial motion in terrestrial phenomena.

However, although Aristotle offers two explanations for how the Sun generates heat, he does not provide a clear account of how this heat reaches the Earth's surface. In traditional thought, change occurs through direct contact, yet this view conflicts with Aristotle's claim that the upper regions of the atmosphere are colder than the Earth's surface. The requirement of contact for change (*GC* I.6, 322b21–25) is hard to reconcile with his assertion that the higher atmosphere is cold (*Meteor* I.3, 340a26–32) and the traditional assumption that heat transfer requires proximity (*Meteor* I.12, 348a14–18). Moreover, if heat is transferred efficiently downward, Aristotle faces another explanatory challenge: heat naturally causes matter to become lighter and rise, as observed in the ascent of steam (see *Meteor* I.9–10). If heat tends to ascend, how does the Sun's heat effectively warm the Earth? To address this, Aristotle hypothesizes the existence of rays that transport heat, implying that the heat carried by these rays differs from the general heat present in the upper atmosphere (*Meteor* I.3, 320a26–32). However, Aristotle's account of light does not fully explain how light itself is generated, leaving a gap in his explanation of solar heating. As Freudenthal also notes, Aristotle does not present a fully coherent mechanism for how the Sun heats the sublunary world.[224] Nevertheless, despite these difficulties in understanding the Sun's heat production, Aristotle employs efficient causation to explain the Sun's role as the efficient cause of warming the terrestrial sphere. While his account remains incomplete in certain respects, it underscores his broader commitment to explaining natural processes through causal principles rather than attributing them to mere necessity or coincidence.

Accordingly, these two explanations show the efficient causal processes of the

[224] See Freudenthal (2010, 239).

Sun producing heat to the sublunary world: the first explanation supposes the motion of the Sun produces heat by inflaming the air, and then the elemental fire surrounding the air is often scattered by the motion of the Sun and driven downwards to Earth in spite of itself; while the second explanation proposes the revolving Sun produces fire by the friction between it and the air underneath. Although these two explanations express different ways of the Sun producing heat and Aristotle does not express which explanation he most prefers, both of these two explanations explain the same fact that the heat in the sublunary world is produced by the motion of the Sun. Thus, it seems that Aristotle utilizes the efficient cause to explain how the Sun generates heat, and specifically the fact that the Sun acts as the efficient cause by warming the terrestrial sphere.

By this point, it is plain that Aristotle utilizes the efficient cause to explain the process of the Sun generating heat to the terrestrial world; now I move on to explore the more specific process in which the Sun acts as an efficient cause to the occurrence of the meteorological phenomena in the sublunary in virtue of two exhalations:

> When the Sun warms the earth the exhalation which takes place is necessarily of two kinds, not of one only as some think. One kind is rather of the nature of vapor, the other of the nature of a windy exhalation. That which rises from the moisture contained in the earth and on its surface is vapor, while that rising from the earth itself, which is dry, is like smoke.
>
> *Meteor* I.4, 341b6–9 (trans. E. W. Webster)

In this passage, the Sun acts as the efficient cause by means of the two exhalations: the first kind is of the nature of vapor, which can be called wet exhalation; and the other is of the nature of wind, which can be called dry exhalation[225]. When the Sun warms the earth, the two kinds of exhalations occur and affect the phenomena which take place in the upper atmosphere. Aristotle points out that when meteorological phenomena are formed in the upper region of the sublunary world, it is due to the combustion of the dry exhalation (*Meteor* I.4, 342a16–20). When it takes place at a lower level in the sublunary world, it is due

[225] In the relevant passage in *Meteorology*, it seems that Aristotle merely hints at the two exhalations; more investigation is necessary since these two exhalations are indispensable part of the continuous efficient causal chains from the heat produced by the Sun to the sublunary world in the field of meteorology.

to the ejection of exhalation by the condensing and cooling of the wet exhalation, for the latter as it condenses and inclines downward contracts, and thrusts out the hotness and causes it to be thrown downwards. Aristotle emphasizes that the motion is upwards or downwards or sideways with respect to the way in which the exhalation goes and its disposition in respect of breadth and depth. In most cases, the direction is sideways since two motions are involved, a compulsory motion downwards and a natural motion upwards, and under these circumstances an object always moves obliquely. Hence the exhalation is considered to be the cause for all these phenomena in the atmosphere.

Furthermore, these two exhalations are closely related to Aristotle's theory of the four elements and their transformations[226]. The dry exhalation and the wet exhalation can mix to form the air. And given that all matter in the sublunary world must generate and corrupt into opposites and the heat in the upper layer should cool or moisten before it falls, when lots of exhalation is brought down to earth by the heavenly motions[227], wet exhalation is capable of condensing into water in its own circle of change, while dry exhalation is capable of condensing into earth in its own circle of change[228]. In this way, both the dry exhalation and the wet exhalation may transform into its sublunary element. And, even if these two exhalations simply return to earth in their own form, the balance of the sublunary world will still be maintained[229]. It should be noted that Aristotle believes that fire can be caused merely by dry exhalation, because the amount of water on earth is insignificant compared to the size of the heavenly realms, and if the water nourishes the stars, then burning would cause the oceans to evaporate completely[230]. Moreover, Aristotle has convincing reasons for the backflow of dry

[226] For the elemental transformations in the four sublunary elements, see also chapter 3.3.1.

[227] In fact, Aristotle thinks that we rarely see downward movement of dry exhalation in the phenomena of meteorology, so he did not do too much investigation on it. For instance, even if lots of dry exhalation is churned back to Earth by the heavenly motion, Aristotle does not say how it got back to Earth (see *Meteor* I.4, 341a30–31.

[228] See *Sens* V.4, 443a21–31 and *Meteor* I.4, 342a27–29.

[229] There is also the meteorological case that rain absorbs the dry exhalation, which falls into sea as salt water, so, this transition happens to balance out the exhalation of the ocean (see *Meteor* II.3,358a24-29).

[230] In order to understand Aristotle's dry exhalation, the most difficult thing is what happens after it rises from the ground and produces the meteorological phenomenon of wind and fire. These winds may rise to the outermost layers of the atmosphere, but according to Aristotle's description of shooting-stars and lower comets, these exhalations burn up and disappear, but when judging from his view about matter, it should be transformed into some other form of matter. (See *Meteor* II.4)

exhalation to the earth. He emphasizes that rain and its congeners are part of the cycle, 'rivers of the oceans', and he refutes the arguments of predecessors that claim water on earth is being constantly consumed by the heavenly bodies[231]. He also noted that when dry exhalations arise from the earth, their source decreases. Therefore, no matter how slow this process is, the earth should be completely transformed into exhalation and disappear. More importantly, it should be noted that these two exhalations are incapable of mutual transformation, since Aristotle rejects the moistening of the dry exhalation into vapor while he holds that fire can only arise from dry exhalation, so as to avoid a possible transformation of dry and wet exhalations[232].

By this point, according to the discussion about the role of the two exhalations, it seems to me that the heat produced by the Sun functions as the efficient cause of all generation and corruption (including all the phenomena in the atmosphere) in the sublunary world through two exhalations, thus organizing continuous efficient causal chains from the Sun to the meteorological phenomena in the sublunary world.

3.3.2 The Continuous Efficient Causal Chains between the Celestial World and the Sublunary World in Meteorology

Having examined the role of the Sun as the efficient cause through warming the sublunary world and having investigated the more specific process that the Sun operates as an efficient cause to the occurrence of the meteorological phenomena in the sublunary world in virtue of the two exhalations, it can be seen that there are continuous efficient causal chains between the celestial world and the sublunary world. More importantly, Aristotle clearly says that the Sun is the main efficient cause of the motions and changes in the sublunary world:

> The efficient and chief and first of the principles is the circle in which the Sun moves. For the Sun as it approaches or recedes, obviously causes

[231] See *Meteor* II.4.

[232] On the impossibility of mutual transformations between wet and dry exhalation, see Wilson (2013, 57–60),

dissipation and condensation and so gives rise to generation and destruction.

Meteor I.9, 346b23–25 (trans. E. W. Webster)

According to this passage, the efficient cause of generations and corruptions in the sublunary world is identified to be the motion of the Sun, which is also considered one of the main influences of the celestial world on the sublunary world[233]. The Sun warms the earth by producing heat in the sublunary world, and produces two kinds of exhalations which effectively cause all the meteorological phenomena in the sublunary realm. For instance, the meteorological phenomenon of rainfall cycles is also caused by the motion of the Sun acting on the elements in the terrestrial world. When heat rises, moisture rises, and when it gets cold, the moisture descends to the ground. These processes, in some cases, have special names to distinguish their varieties: when water drops into small droplets, it is called drizzle; and when the drops are larger, it is rain (*Meteor* I.9, 347a9–12). Moreover, the motion of the Sun brings about seasons' changes[234] and keeps the four elements from settling into four stable, changeless, and concentric spherical layers (*DC* II.3, 286b1–9). In addition, there are also some specific phenomena which are caused by the Sun's motion. Aristotle occasionally refers to a special phenomenon caused by the Sun's motion, namely, land changing into sea or sea into land, which is an ordered phenomenon produced by the Sun as an efficient cause, since the regions of the earth experience periodic aging and rejuvenation according to the amount of wet exhalation present in the ground (*Meteor* I.14, 351a30–b35). Thus, the change of land into sea and vice versa, is caused by the hot and cold in the earth, which are caused in turn by the Sun and its revolution, thus this special phenomenon could also be treated as the Sun's influence as an efficient cause. Therefore, it is clear that continuous efficient causal chains exist from the Sun to the sublunary world with respect to the fact that the Sun is thought to be the main efficient cause of the meteorological phenomena in the sublunary world.

By this point, I have discussed the continuous efficient causal chains from the Sun to the sublunary world in the field of meteorology, but what is the role of other heavenly bodies in the sublunary world? In fact, Aristotle explicitly says that

[233] See also *GC* II.10–11.

[234] Aristotle adds to the Sun's simple diurnal revolution its annual northern advance and southern retreat, which explain seasonal changes and climatic differences (see *Meteor* I.2, 339a20-22).

more than one circular body is necessary for generation (*DC* II.3, 286b5–8), which means that the Sun is not the only heavenly body that acts on generation and corruption in the sublunary world. Moreover, Aristotle considers the heavenly bodies to be the source of all motions and changes in the sublunary world, and supposes that the sublunary world necessarily has a certain continuity with the upper motions since its power is derived from them (*Meteor* I.2, 339a22–28). Moreover, Aristotle illustrates many meteorological cases of the generation and corruption in the sublunary world, which are caused by the motion of the Sun (*Meteor* I.14, 351a30–b35). Since Aristotle considers the heavenly bodies to be the efficient cause of all generations and corruptions in the sublunary world, it is necessary to explore the role of other heavenly bodies which work as efficient causes of generation and corruption in the sublunary world. However, Aristotle has mentioned only some few phenomena which he believes are caused by other heavenly bodies. For instance, Aristotle treats the Moon's motion as the cause of the timing of women' menses (*GA* II.4, 738a8–18). The uterus's region within the female body includes two blood-vessels, the great vessel and aorta, which are divided higher up, with many fine vessels terminating in the uterus. Since they transmit many nutrients, female nature is incapable of concocting them since it is colder than the male's nature, and therefore when blood flows into the uterus through very thin blood vessels, these vessels are incapable to receive the excessive quantity because of their narrowness, and the result is a sort of hemorrhage. A woman's menstrual cycle is not precisely defined, but it tends to return during the waning of the Moon. Aristotle thinks this is what we should expect because the bodies of animals get colder when the environment gets colder, and the time of change from one month to another is colder because of the absence of the Moon, which also causes more storms at this time than in the middle of the month. Moreover, Aristotle also considers the Moon's motion to be the efficient cause of earthquakes (*Meteor* II.8, 367b20–b31). Earthquakes sometimes coincide with an eclipse of the Moon because as the Moon's path approaches the point where the eclipse of the Moon occurs, the Moon's heat decreases, causing earthquakes. More precisely, when the earth is on the verge of being interposed, but the Sun's light and heat have not completely disappeared from the air but are gradually disappearing, the winds that cause earthquakes enter the earth before the eclipse, and calm follows. And because there is usually wind before an eclipse: at nightfall if the eclipse occurs at midnight, and midnight if the eclipse occurs at dawn. They are caused by a drop in the Moon's temperature as the Moon's path

approaches the point at which the eclipse will occur. Thus, the influence of suppressing and calming the air is weakened, the air moves again, and the later the wind rises, the later the eclipse will be. Therefore, although Aristotle does not say so much about the other heavenly bodies' influence on the sublunary world, he supposes the heavenly bodies to be the efficient cause of all generations and corruptions in the sublunary world.

Eventually, according to the discussion above, we now come to the conclusion that continuous efficient causal chains exist from the heavenly bodies to the sublunary world in the sense that the heavenly bodies are the efficient causes of all generations and corruptions in the sublunary region. Thus, through the efficient causal chains from the celestial region to the sublunary realm there is a causal connection between these two regions, and therefore Aristotle's efficient cause can ensure a unified explanation in the field of meteorology.

3.4 The Role of Efficient Causation in Achieving a Unified Explanation in Aristotle's Biology

In the discussion above, I have investigated the role of Aristotle's efficient cause in a unified explanation in the field of cosmology, both with regard to the motions of the elements and in the field of meteorology, that is, at the level of the inanimate world. In this section, I will turn to explore the role of the efficient cause to a unified explanation at the level of the animate world, namely, in the field of biology. It should be noted, however, that some scholars have doubted whether the efficient cause can fully explain the existence of living things[235].

[235] For instance, Gotthelf (1987b, 225–231) claims that Aristotle is motivated to stress the final cause in scientific explanation because of the impossibility of fully explaining living things according to other causes, namely efficient cause. In my view, Gotthelf is arguing that for the explanation of living things a final cause is necessary in addition to a natural action and interaction of the elements. For instance, see p.225: "Given the simplicity of Aristotle's chemistry, he can only believe that the outcome of organic development is too complex, too orderly, possessing too much of limit, logos, and form, to be the result merely of the unlimited, relatively indefinite natural action and interaction of the elements. The development must be for the sake of its outcome – i.e., essentially and irreducibly a development to order – i.e., to form. The development, in short, must be the actualization of the irreducible potential for form." See also p.231: "the potential is 'irreducibly' for some complex end when the production of that end is not due wholly to the actualization of element-

For the role of the efficient cause in Aristotle's biology, it seems that there are efficient causal chains from the heavenly bodies to the generation of living things in the sublunary realm, since in Aristotle's work there are various passages that describe the role of the heavenly bodies as the efficient cause of these things. For instance, Aristotle has a famous perspective that 'a human being is produced by a human being and the Sun'[236], and it seems that the heat produced by the Sun is the efficient cause of the generation of human beings. Moreover, the case of spontaneous generation, which cannot be explained by the final cause[237], can be explained through the efficient cause, since according to Aristotle it is brought about by the heat produced by the Sun[238]. Besides, the length of the life of an animal species is also taken to depend on the motion of heavenly bodies[239]. Therefore, in this section, I will first investigate the role of the heavenly bodies[240] as efficient causes to the generation of living things, and then I will examine whether there are continuous efficient causal chains to guarantee the unified explanation of the universe in the field of biology.

3.4.1 The Continuous Efficient Causal Chains from the Celestial World to the Sublunary World in Biology

For the investigation of the role of the efficient cause to a unified explanation in the field of biology, the most important part is the exploration of the role of the

potentials." Similarly, Johnson (2005, 185) believes that the living things could not be explained without the appliance of final cause. Charles (1988, 8–9) implies that there may exist the possibility that physical coherence is sufficient in Aristotle's biology, but he does not express this thought. Cooper (2009, 203–204) further indicates the first kind of principle is considered to be the final causal principle which can be applied to the natural kinds of living things to govern their development and behavior. Moreover, Cooper implies the second kind of principle is considered as an efficient causal principle to govern living things' behavior in given conditions. In my interpretation, Cooper seems to have realized the specific role of efficient cause to be applied to the scope of biology.

[236] See *Phys* II.2, 194b13; *Meta* XII.5, 1071a15; *GA* IV.10, 777b35.

[237] For the detailed discussion on the limited role of final cause in spontaneous generation, see chapter 2.5.3.

[238] See *GA* III.11, 762a19–32.

[239] See *GA* IV.10, 777b10–19.

[240] Since Aristotle rarely discusses the role of other heavenly bodies (except the Sun) to the generation of living things, in this section I mainly investigate the role of the Sun to the generation of living things.

vital heat[241] produced by the Sun which acts as the efficient cause to the generation of living things in the sublunary world[242].

In *GA*, Aristotle puts forward the notion of 'vital heat' (θερμότης ψυχική) (*GA* III.11, 762a20) and defines the heat produced by the Sun as such[243]. His notion of 'vital heat' is developed on the basis of Socrates' views concerning the heat produced by the Sun[244], and distinguishes the vital heat produced by the Sun from the ordinary heat generated by the Sun with respect to their different functions of 'concoction'. According to Aristotle, 'heat' is an active factor which acts on the passive ones, and brings about the process of 'concoction'[245]. He considers all processes of 'concoction', whether natural or artificial, to have in common that they combine things of the same kind to result in a homogeneous substance, and thus foreign objects, such as ashes and residues, are eliminated. This kind of process leads to a homogeneous substance with uniform texture throughout and which has the characteristic ratio of its components[246]. In this process, some

[241] Aristotle clearly puts forward the concept of 'vital heat', extracting the 'vital heat' from the heat of the Sun for research and giving it the role of generating living things. Although Aristotle himself did not explicitly put forward the concept of 'ordinary heat', his theory of the heat produced by the Sun actually divides the heat produced by the Sun into 'vital heat' and 'ordinary heat'. For this distinction, see also Longrigg (1975, 213–214).

[242] Aristotle clearly puts forward the concept of 'vital heat', extracting the 'vital heat' from the heat of the Sun for research and giving it the role of generating living things. Although Aristotle himself did not explicitly put forward the concept of 'ordinary heat', his theory of the heat produced by the Sun actually divides the heat produced by the Sun into 'vital heat' and 'ordinary heat'. For this distinction, see also Longrigg (1975, 213–214). And I have also discussed the role of the heat produced by the Sun as an efficient cause to the generation and corruption in the sublunary with respect to the field of meteorology (see chapter 3.3).

[243] See *GA* II.3, 736b32–737a5: in all cases the semen contains within itself that which causes it to be fertile—what is known as "vital heat" substance, which is not fire nor any similar substance, but the pneuma which is enclosed within the semen or foam-like stuff and the natural substance which is in the pneuma; and this substance is analogous to the element which belongs to the stars.

[244] In *Memorabilia* IV 7.6–7, Xenophon describes how Socrates deplores the insanity Anaxagoras showed in attempting to explain the phenomena of the heavens and in claiming that the Sun is fire, and accuses Anaxagoras of utter ignorance in failing to observe the vast difference between fire and sunlight –clearly implying that the heat of the heavenly bodies is far superior to fire. Aristotle himself, like Socrates in this passage, distinguished two types of heat when he claimed that the heat in living things is more akin to the element of the stars and the heat of the Sun than to ordinary fire (*GA* II.3, 736b33–737a7). Obviously, in talking of the vital heat, Aristotle distinguishes vital heat from ordinary on purpose, and meant them to be different kinds of heat from the Sun. He could easily have assigned it a dignity far above that of the material substances we encounter in our immediate environment. On the discussion on heat in Xenophon's *Memorabilia*, see Hahm (1982, 63).

[245] See *GC* II.2, 329b24–31; *Meteor* IV.1, 378b10–25; and *GA* I.18, 724b20–27.

[246] Freudenthal (1995, 22).

moisture evaporates or some dry matter is mixed with moisture, and thus the emerging substance gradually acquires a definite shape. The process will eventually serve the purpose of establishing some sort of stable mark between moist and dry, in which the substance acquires an appropriate form or nature. Therefore, the concoction process produces a specific substance in which moisture has been controlled in a characteristic way: further heating destroys it, sometimes transforming it into another substance. Indeed, it seems that the concoction process is the process of turning a loose heap into a unified and organized whole. Aristotle also brings forward ripening as a process of concoction since we call it ripening when there is a concoction of nutriment in fruit. And since the concoction process is a sort of perfecting process, the process of ripening is perfected when the seeds in the fruit are capable of reproducing the fruit in which they are found. More importantly, his typical demonstrations of the concoction process seem to be those which are produced in living things (*Meteor* IV.3, 380a18–26). Vital heat in the heart, stomach and other places continuously transform food first into blood, and then into part of animals' organs, such as flesh and bone, while the excess blood is further concocted into fat, menstruation, semen, etc. Therefore, under the influence of the concoction process of vital heat, a variety of foods are transformed into different living substances, each with its own unique form and nature. A similar situation occurs during the ripening of fruit, as plants also tap into the vital heat. Thus, it can be seen that the concoction process of 'vital heat' is the process of turning a bunch of loose matter into a unified and organized whole. This concoction process is the generating process of living things, while the concoction process of 'ordinary heat' is incapable of generating living things.

Now it is clear that the vital heat produced by the Sun acts as the efficient cause in the process of the generation of living things. However, vital heat not only provides 'heat' to promote the generation of living things, but also plays an important role in the formative process of living things. Aristotle says that vital heat is not ordinary heat—rather it is formative heat, the embodiment of soul[247] (*GA* II.3, 737a1–7). The vital heat produced by the Sun does affect the living being's generation by operating through semen or any other natural residue that

[247] Because of its formative power, vital heat can be considered as the embodiment of soul. According to the formative process of living beings, we can find how vital heat operates on the formative process of living beings as the embodiment of soul. See also Freudenthal (1995, 116) on vital heat as the embodiment of the soul in Aristotle.

may have within it a principle of life. In living being's formative process, vital heat has the formative power, which operates as the embodiment of the soul, to inform the proper matter to be a living thing.

In order to have a better understanding how vital heat operates itself as the embodiment of soul in the formative process of living beings, it is needed to focus on his discussion of animal's reproduction. The most typical example of vital heat's formative process is the process by which semen acts on menstruation (*GA* IV.3, 767b17–21; 768a21–27)[248]. According to Aristotle, the offspring is endowed with its form from a male parent, through the vital heat it had received during the concoction in the male's body, informing the matter provided by the female (the menstrual fluid). When the generative residue in the menstrual fluid is properly concocted, the movement imparted by the male will make the form of the embryo in the likeness of itself. The condition under which this happens is that the semen carries enough vital heat to fully grasp the relatively cold female matter: the vital heat thus generates in the matter the most perfect form, that of the father. However, assuming that the causal dependence of the form of the offspring rests on the vital heat of the male parent, then the vital heat of the male parent determines the characteristics of offspring, especially the sex of the offspring. Moreover, Aristotle emphasizes that the successive reductions in the male parent's vital heat lead to a series of declines in the quality of the offspring, extending from the most perfect form (similar to the father) to the lowest form (the monster). Therefore, the vital heat appears as a physiological factor in the form of living things, because the more active the heat, the more perfect the form. According to Aristotle, changes in the vital heat carried by a male's semen lead to corresponding changes in the perfection of the resulting form of the offspring. Thus, Aristotle interprets the vital

[248] Although many scholars have discussed this formative process, they do not mention the important role of vital heat in this process. Peck (1953, 111–121) indicates the action by which matter is informed is often referred to by Aristotle as 'setting' process, and says that 'setting' (see *GA* II.4, 73923;729a10f.; IV.4, 771b24f.) is most typically brought about by semen, which acts on menstruation. However, although Peck is aware of the role of semen in the informed process, he ignores the role of vital heat in this process. While Balme (1987, 291–312) does realize the fundamental difference between animals is the difference in their natural heat, he does not realize it is Aristotle's 'vital heat', nor discuss its formative process. In his study of Aristotle's theory of animal reproduction and embryology, Cooper (2009, 174–203) aims at showing that Aristotle did intend his biological theory of forms to be a continuous development and extension of whatever theory of substantial forms he meant to be the upshot of his discussion in the central books of his *Metaphysics*. But Cooper did not pay attention to the formative process of the generation of animals. Furth (1988, 114–118) has also described the biological process of the generation of living things, but he does not mention its formative process.

heat as an informing power, which is also confirmed by his description of 'spontaneous generation', for instance, generation in the absence of semen. The generation of animals in decaying animal matter is attributed to the vital heat produced by the matter through concoction:

> Now all things formed in this way, whether in earth or water, manifestly come into being in connexion with putrefaction and an admixture of rain-water…Animals and plants come into being in earth and in liquid because there is water in earth, and air in water, and in all air is vital heat, so that in a sense all things are full of soul. Therefore, living things form quickly whenever this air and vital heat are enclosed in anything.
>
> *GA* II.11, 762a10–23 (trans. A. L. Peck)

It seems that the vital heat derived from the Sun is sufficient to give form to matter, just as the vital heat carried by semen in spontaneous generation. Also, for spontaneous generation, Aristotle explains that animals and plants come into being on earth and in liquid since there is water in earth, and air in water, and in all air is vital heat, so in a sense, everything is full of soul. Thus, living things form quickly whenever this air and vital heat are enclosed in anything. When they are so enclosed, the corporeal liquid is heated, and there arises as it were a frothy bubble. Whether what is formed is to be more or less honorable in kind depends on the embracing of the vital heat. Aristotle describes this process in two stages. First, the heat of the Sun heats matter (an enclosed quantity of water and earth), thereby endowing it with vital heat; and then, the vital heat in turn leads to the formation of plants and animals. The reason why vital heat is capable of generating living things is that vital heat has the capacity to generate souls. The vital heat also operates in the body of animals, more precisely, vital heat works not only in the semen of animals, but also regardless of any other residue of the animal nature there may be, there is still a vital principle (namely vital heat) in it (*GA* I.3, 737a3–5). Moreover, in the case of spontaneous generation from putrefying matter, for instance, in rennet and fig juice, it is the vital heat inside that allows them to inform suitable matter on which they come to act in the process of concoction of living things. Therefore, vital heat has the formative power, which not only heats, but also informs the proper matter to be a living thing, and

it can be seen that more vital heat produces more perfect forms.[249]

Then I move on to investigate the role of vital heat in determining the scale of living things[250]. Aristotle hypothesizes a general rule that the vital heat determines the scale of living things and supposes that more perfect animals are those which are by their nature hotter and more fluid and not earthy (*GA* II.1, 732a15–733b17). This means that more vital heat brings about greater perfection, greater motive power and therefore greater size and mobility, and more fully developed offspring. And this also means that more vital heat provides greater strength. Considering that the scale of living things depends on the attribute of vital heat as the fundamental underlying factor, we can perceive it as the scale of the soul of living things. Therefore, vital heat is also the basis for determining the scale of living things. In this sense, with respect to vital heat, the scale of living things could be divided as follows. Firstly, in the scale of living things, the lowest is the plant, which has the least 'vital heat'. Plants obtain a certain 'vital heat' from the Sun, but the vital heat obtained by plants is less than that of animals (*PA* II.3, 650a5–15). The second is animals, which are endowed with more vital heat than plants. So, the scale of animals is higher than that of plants. The third is man. Aristotle believes that man is the only upright animal since man is endowed with the greatest quantity of vital heat[251], and has a unique rational thinking ability (*PA* IV.10, 686b10–25). In Aristotle's thought, more vital heat leads to a more upright position, and therefore to diminished earthiness and to purer blood, which in turn leads to keener perception and intelligence, as well as an increase in certain physical capacities, such as movement. In sum, an animal is more perfect when it has a greater proportion of vital heat. In addition, Aristotle supposed that the reason why some creatures have this part (lungs), and why those having it need

[249] Aristotle clearly says that the vital heat comes from the heat which is generated by the Sun, but in his treatises, he does not mention where the vital heat takes this generative form from.

[250] For the relation between vital heat and the scale of living things, see, for instance, Balme (1987b, 10–11), who noticed that Aristotle interpreted vital heat as a key indicator of the difference between higher and lower animals. Ross (1995, 113–116) comments that Aristotle has established the close relationship between the vital heat in living things and the scale of living things, and in fact Aristotle built the concept of the latter on the basis of the former, therefore theoretically tying together a number of otherwise unrelated factors of living things.

[251] See also Balme (1987b, 10–12), who has also discussed the generation of human beings in Aristotle and comes out with the conclusion that humans are generated by humans since humans are endowed with different natural heat from other living beings. For Aristotle's discussion that a human being is produced by a human being and the Sun, see *Phys* II.2, 194b13; *Meta* XII.5 and 1071a15; *GA* IV.10, 777b35.

respiration, is that the higher living things have a greater proportion of vital heat. And that at the same time they must have been endowed with a higher kind of soul, and they are on a higher scale of nature than plants [252]. Therefore, it can be seen that an animal which has more vital heat has a higher soul and is placed higher on the scale of living things, suggesting that the differences of vital heat establish a hierarchy of souls. The same results also come from the analysis of the effects of changes in the vital heat of semen on subsequent offspring. The greatest vital heat also produces the most perfect form, which is a male resembling the male parent, and the successive reduction of the vital heat leads to a decrease in the perfection of the form of the offspring. So, it can be seen that vital heat determines the scale of living things[253].

According to the discussion above, the vital heat produced by the Sun acts as an efficient cause in the generation process of living things, which can be considered as the embodiment of the soul and has the formative power to inform the proper matter to be a living thing, and also determines the scale of living things. Thus, there are continuous efficient causal chains from the celestial world towards the field of biology through the vital heat produced by the Sun.

3.4.2 The Continuous Efficient Causal Chains from Vital Heat to the Body of Living Things

Having examined the role of the vital heat produced by the Sun as an efficient cause to the generation of living things and its formative power in generating living things, now I go on to explore the specific efficient causal chains from the vital heat to the body of living things, especially to the body of animals. As I have discussed above, for Aristotle, vital heat is the embodiment of the soul and has the formative power to inform the proper matter to be a living thing, and also determines the scale of living things. And it is precisely because of the role of vital

[252] See *Resp* 19, 477a13–24.

[253] With greater and purer vital heat, a more perfect and higher form arises. This explanation of the scale of living things supposes that the realm of living things is continuous, since when comparing the scale of living things to the measure of vital heat, a continuous curve appears. In fact, Aristotle repeatedly and clearly assumes that the scale of living things is continuous, from the lowest form to the highest form of living things. See *HA* VIII.1, 588b2–589a15; *PA* II.10, 656a2–10 and IV.5, 681a10–30.

heat inside the living things' bodies that their forms are preserved, in other words, the destruction of vital heat means the destruction of the living thing's form (*Meteor* IV,11, 389b5–15; *PA* II.9, 654b6–18). For example, when blood, semen, or bone marrow lose the vital heat, they also lose their intrinsic properties, as they have only material elements, but lose their form. Therefore, vital heat is of great significance for the existence of life forms. But how does vital heat work within a living thing's body? It depends upon the specific efficient causal chains from vital heat to the living thing's body, typically in an animal's body.

In order to explore these efficient causal chains, it is necessary to examine an important assumption about the heart. Aristotle supposes that the physical part where the form of living things is located is the heart, which is the center of the body and can undertake all the capacities of living things[254]. In this sense, the heart is treated as the most important organ of living things since it is the concrete location of the forms of living things. Moreover, vital heat from the Sun is stored in the heart of the living thing and is continuously transported from the heart to the various parts of the body. However, vital heat is not a substance, and thus it cannot be assumed to move on its own, since 'heat and straightness can be present in every part of a thing, but it is impossible that the thing should be nothing but hot or white or straight; for, if that were so, attributes would have separate existence' (*Long* 3, 465b10–15). And even if it were a substance, it could not have a natural movement to all the parts of the body. It seems that what Aristotle is trying to emphasize here is that whatever the vital heat is, vital heat cannot move itself, nor can it move naturally to all parts of the body. Therefore, according to Aristotle, the movement of vital heat in the living thing's body must rely on some matter, since vital heat cannot naturally move to all parts of the body. In this regard, a question arises: by means of what substances and through what channels does the vital heat in the heart reach all parts of the body to maintain the form and function of living things?

For this question, Aristotle supposes that inside the body, there is only one network of transport: blood vessels. He believes that blood or something similar is transmitted throughout the whole body[255], so that vital heat must be transmitted to all parts of the body through the blood vessels as transport channels. Obviously,

[254] See *Motu* 9, 703a1–5; 10, 703a31–37; *DA* II.8, 420b21–29.

[255] See *PA* II.1, 647b2–10; II.3, 650a30–38; III.5, 668a4–20.

taking into account that blood flows in the blood vessels, the question arises whether the vital heat is transmitted to various parts of the body through the blood in the blood vessels? Aristotle himself, however, makes clear that the blood itself does not have the role of transporting vital heat[256], so vital heat is not transmitted through the blood. Moreover, Aristotle has also mentioned in *Politics* that blood is not essentially hot (*Pol* I.2, 1252b1ff). The vital heat derives its heat from the Sun, so vital heat itself has the property of heat, which further proves that it cannot be the case that vital heat is transmitted through the blood taking into account the fact that blood is not essentially hot. However, since blood vessels are the only network channels leading to the whole body, vital heat needs to reach all parts of the body through blood vessels. Therefore, taking into account that vital heat cannot be transmitted through blood, we are left to wonder how the vital heat is transmitted to various parts of the body?

This question needs to be linked to another important concept in Aristotle's thought: pneuma (πνεῦμα). As discussed above, in living being's formative process, vital heat has the formative power, which operates as the embodiment of the soul, to inform the proper matter to be a living thing. The vital heat does affect the living being's generation by operating through semen or any other natural residue which there may be that has a principle of life within it. Aristotle says that in all cases the semen itself contains a substance owing to which it has the ability to generate; this substance is neither fire nor anything like that, but is encapsulated in semen or a foam-like substance which is considered as the substrate of vital heat (*GA* II.3, 736b13–21). This is also the reason why ordinary heat cannot generate any living thing while vital heat can. This special substance is pneuma.

Pneuma is produced naturally and continuously through the action of vital heat on the blood, and the existence of pneuma is the inevitable consequence of the presence of both liquid and heat. The vital heat is active while the liquid substance is acted upon (*GA* II.6, 742a9–20). Moreover, from the viewpoint of physics, the phenomenon is similar to the formation of vapor through boiling, since 'boiling is due to the volatilization ('pneumatization') of the fluid by heat' (*Resp* 26, 479b26–30). Thus, pneuma serves as the medium through which vital heat is distributed throughout the body. According to Aristotle, pneuma—composed of tiny bubbles of warm air inherently present in the blood—acts as the vehicle for carrying vital

[256] *PA* II.1, 647b2; II.3, 650a35; III.5, 668a4f.

heat to every part of the living organism. Since Aristotle states that all pneuma contains vital heat (*GA* III.11, 762a15–25), pneuma is not merely a passive substance but plays an active role in sustaining the physiological processes of living beings. However, rather than being simply the material substrate of vital heat, pneuma functions as the instrumental carrier through which vital heat is distributed. Moreover, vital heat and pneuma exist in a dynamic interplay: vital heat acts upon the blood, generating pneuma as part of an ongoing physiological process, ensuring that the transmission of vital heat remains continuous throughout the body. This reciprocal relationship allows vital heat to be both dependent on and sustained by pneuma, without reducing pneuma to a mere product of vital heat. Aristotle's biological model thus presents pneuma not as the underlying substrate of vital heat but as its conduit, facilitating its circulation and ensuring the vitality of the organism.

As a result, vital heat exists in the heart and is transported to various parts of the body through the blood vessels. Even though vital heat cannot be transported through the *blood* in the blood vessels, it can through the pneuma. Moreover, vital heat continuously acts upon the blood, ensuring that pneuma remains present and actively engaged in physiological processes. vital heat depends on pneuma for its transmission, while at the same time, it sustains and actualizes pneuma within the living organism. In this way, pneuma ensures the continuous circulation of vital heat, supporting the physiological functions necessary for life. In addition, Aristotle assumes the semen contains the substance of pneuma that which causes it to be fertile (*GA* II.3, 736b30ff). So, it is the pneuma that has the ability to transmit vital heat to all parts of the body, and it is also the pneuma which contains vital heat in the semen, providing the semen with the generative power.

Accordingly, it is clear that there are continuous efficient causal chains from the vital heat produced by the Sun to the living thing's body. Vital heat operates as an efficient cause to the generation and maintenance of living things in the field of Aristotle's biology, since pneuma is considered as a substance which provides a base to the power of vital heat. Thus, the efficient cause can guarantee a unified explanation in this field.