Sex, Blood, and Soul:
The Transmission of Form in Aristotle's Biology

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1 Introduction

In his biology, Aristotle is committed to the principle of "like begets like"; that is, species reproduce according to kind. In the *Parts of Animals* and especially in the *Generation of Animals*, he seeks to give an explanation of how and why this process should work this way. In particular, he is committed to there not being some external agent that causes men to beget men and dogs to beget dogs, but that there is some principle or principles working within the parents that ensures the faithfulness of their offspring's species.

One question that arises inquires as to the mechanism by which the form of the parent (and in particular, the male parent) gets transmitted to the offspring. In this paper, I sketch an overview of Aristotle's notions of reproduction and growth, vital heat, and the connate *pneuma*. From this basic set of concepts, I describe some of the possible interpretations of what exactly is conveyed from father to child. The main issue (which turns out to be a rather subtle one) is whether this contains form itself or merely some sort of form proxy.

2 Reproduction and Growth of Animals

In the *Generation of Animals* II 1, Aristotle gives an account of why and how the various parts of animals are formed. But to begin, he wants to address the question of why animals are generated in the first place. Aristotle states that the divine is better than that which is not divine, and the nature of the divine is to be eternal. Although species as a whole are eternal, the individuals of

that species are not eternal; they come into being and then pass away after some finite time. So, Aristotle reasons, the generation of animals occurs in order that the species remain eternal, even though the individuals may pass out of existence.

It is in this introductory matter to the chapter that Aristotle also locates the first principle of movement with the male, and the principle of matter with the female. For Aristotle, the male is more divine than the female, since it is the principle of movement that is more divine than that of matter. This thinking carries over into his later discussion of the generation of animals, when he locates the efficient or moving cause of the creation of an embryo in the male semen.

But for now we turn to the discussion of how the parts of animals are formed. Aristotle divides this question into two sub-questions. First, what agency causes the parts of animals to be formed, and second, in what order do these parts come to be. In response to the first question, Aristotle gives two possible answers: either the cause is external (from the parent as well as the offspring, it seems), or it is something in the male's semen. Aristotle rules out the possibility of it being some external agency that causes the generation of the parts of animals.

For his second question, what order do the parts of animals come to be, Aristotle presents two options: they either come to be all at once (in parallel, as it were), or they come to be in succession (in serial). In deciding this question, Aristotle is guided by his observations of actual embryos, wherein he observes that "some of the parts are clearly visible as existing in the embryo while others are not" (GA II 1, 734^a21-22)[1]. So the parts of animals come to be in succession, one after the other.

If the parts develop one after another, does this mean that they cause one another? Aristotle answers this with a profound *no*, on the grounds that the earlier part would need to have within it the form of the thing that it creates, but this is not what we observe. For instance, the heart arises before the liver, but the heart does not contain within itself the form of the liver, so while it precedes the liver, the heart does not cause the liver to come into being. Aristotle likens this to the development of a boy into a man; "a man becomes a man *after* being a boy, not by his agency" (GA II 1, 734^a29-30).

[1]For the list of abbreviations used in this paper, see page 16.

Aristotle here is appealing to a form of the transmission theory, where the "form and character of the later [thing] would have to exist in the earlier" (*GA* II 1, 734^a33). This idea is echoed in the transmission of form from father to child, and is part of the basis for the important Aristotelian principle of "like begets like". There is also a connection here to the fact that the matter and form of a living creature only exist when they are united in that very creature (Code, 1987, p.56). That is to say, there are no free-floating forms (contrary to Plato), and that there is no matter properly speaking without a form as well. Some of what we today call matter would be to Aristotle just so much stuff.

Later in *GA* II 1, Aristotle notes a sort of bootstrapping problem for the generation of animals. Nothing generates itself, but generated things (both animals and plants) increase themselves, for living things must grow. So the first part that comes into being must be that part which allows the animal to increase itself. In other words, the first and only thing the animal receives from the outside is the first principle of movement. Once that principle comes into the matter and creates the heart, then the animal is able to grow and increase on its own.

This bootstrapping problem is solved by having the first movements for growing the creature be provided by the father. One question that should be briefly addressed is why the mother or some power in her cannot kick-start this process. It is a conceivable position that a mother should be able to concoct a fetal heart in her menses, thus leading to a fetation and eventually a child. So why is it that the father is required at all in Aristotle's account of reproduction?

The answer, of course, is rooted in the fact that Aristotle sees the female as inferior to the male. And because of this, the menses are an inferior form of semen. They contain all of the potential for a new animal *except* the moving cause. This alone must come from the father's semen. The semen contributes no matter to the offspring, but only sets up the appropriate motions in the female's matter for the offspring to begin to grow. (*GA* II 3, $737^a28 - 30$)

3 Vital Heat

Vital heat is a very important technical concept in Aristotle's views on the growth and reproduction of living things. So before delving into the intricacies of just how it is that form is transmitted

form parent to offspring, we must investigate vital heat. To begin with, we should briefly look at Aristotle's notion of how the active power of heat works on the passive power of the moist, for this is the basis of Aristotle's account of how the body sustains itself, and (more importantly to the current discussion) how creatures reproduce themselves. Heat concocts the moist matter into a dryer state. At some point, this concoction reaches a point of stability (as laid out by a ratio or *logos*), and what we have can be termed a *homoeomer* or "uniform stuff".

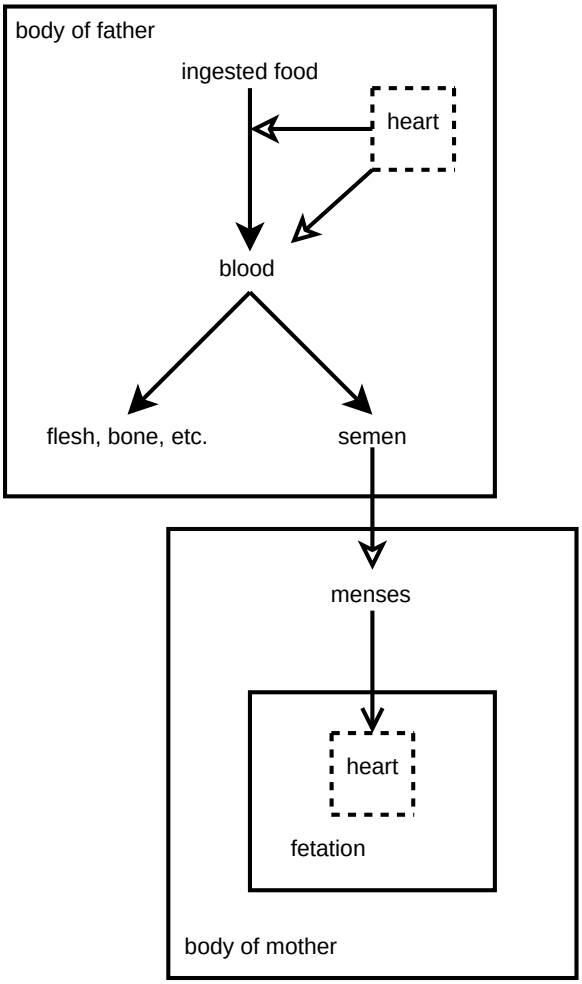
Along this scale of concoction there is not just one stable point, but a number of them. This is critical to Aristotle's notion of the cycles of nutrition and reproduction. When we ingest food, the matter therein is concocted first into blood, and then some of it is further concocted into flesh and other bodily *homoeomers* needed for growth and maintenance of the body.

Some of the blood, however, is also concocted further into semen. This, of course, only happens in the male. The female, according to Aristotle, does not posses enough vital heat to concoct semen. And when the semen comes together with the female menses, the semen concocts the matter of the menses into a heart. The semen is able to perform the function of concocting because it is the result of a concoction process involving vital heat, and during that process it receives some vital heat of its own. The amount of vital heat it receives can vary, and this is what Aristotle believes leads to the types of variations we observe among our offspring.

At this point we should address the issue of what, exactly, vital heat is. Furthermore, we would like to know how it differs from non-vital heat (i.e., plain fire). Vital heat has something to do with form, since "more vital heat produces 'more' form" (Freudenthal, 1995, p.25). I take the phrase "'more' form" to mean roughly a better or closer to perfect transmission or realization of form. Semen with the greatest amount of vital heat yields offspring whose forms are just like their sire; i.e., they are male and strongly resemble him. Less vital heat in the semen leads to less resemblance to the father, and then to female offspring, and finally to degenerate monsters.

Vital heat is not merely the efficient cause of heat or fire, since the concoctions that vital heat performs are governed by some *logos*. This is in contrast with fire, which consumes without bound as long as there is matter for it to work on (i.e., fuel). So now, of course, we can ask from whence this *logos* comes.

Figure 1: The cycle of vital heat in growth and reproduction



Freudenthal (1995) equates the notions of something having vital heat and having nutritive soul. They are, he claims, simply two ways of looking at the same principle. Both mean the ability to transform or concoct matter according to a certain ratio or *logos*. They are both ways of referring to the combination of an efficient cause and a formal cause. Referring to this pairing as "vital heat" draws attention to the efficient cause portion, while referring to it as "nutritive soul" draws attention to the formal cause portion. The efficient cause is the instrument that does the concocting, and is governed by the formal cause. This is supposed to be analogous to our endeavors in the various arts, where we use fire and other tools to transform matter, according to some rules

that we as outside agents impose. But in living things, the rules and the instruments are more tightly coupled; vital heat contains both.

There is a principled reason behind Aristotle's choice of the heart as the seat of the nutritive soul and the ultimate source of an organism's vital heat[2]. The heart is the organ that distributes blood throughout the body, and as noted above, blood is the first substance that the heart concocts food into. And since this is concoction by vital heat, the blood receives some portion of that vital heat. Now recall that vital heat and nutritive soul are equivalent notions. Therefore, because the blood goes throughout the body, it carries soul throughout the body. That is, the heart is what distributes the soul through the body via the blood. This is also why the heart is the first thing that the semen concocts in the menses. Once the heart is concocted by the semen[3], it can take over the process of concoction, and create the blood, flesh, bone, and so forth, for the new organism. And as we can see in Figure 1, the processes of growth and reproduction are for Aristotle simple two small variations on one underlying theme: namely, the concoction of substances by vital heat.

4 Connate *pneuma*

One of the trickier doctrines to understand in Aristotle is that of the connate *pneuma*. Freudenthal (1995) mentions two radically different interpretations of the role of connate *pneuma* in the theory of the generation of animals, both of which he thinks are incorrect, albeit for different reasons. On the one hand he presents Solmsen's account, which sees the introduction of connate *pneuma* as a sort of *deus ex machina* that is relatively unconnected with the rest of Aristotle's account of both *pneuma* and the rest of his biology. As Freudenthal puts it, "Solmsen thinks vital (which is also generative) heat alone cannot effect the transmission of soul" (Freudenthal, 1995, p.111). Something else is needed, which is the connate *pneuma*. As we shall see, Freudenthal largely agrees with this statement; his main criticism of Solmsen's account is that too much of its "explanatory power remains in the dark" (Freudenthal, 1995, p.111).

On the other hand, Freudenthal that although Balmes's account has the benefit of avoiding

[2]At least within that organism itself. There may be something to be said for the idea that the sun is the truly ultimate source of vital heat for *all* things, but I will not go into that in any detail here.

[3]Or more accurately, something *in* the semen, as we shall see.

the *ad hoc* nature of Solmsen's explanation, actually goes too far in its assimilation of connate *pneuma* into the rest of Aristotle's biology. It in fact equates the connate *pneuma* with vital heat. Since the entire explanation of the generation and growth of animals can be explained in terms of vital heat, the connate *pneuma* thus seems to be an extraneous addition on Aristotle's part. Freudenthal is reluctant to take this approach, as it turns the theory of connate *pneuma* into a completely spurious doctrine. In addition, by taking an almost purely biological view of the connate *pneuma* ("he identifies fire with vital heat" (Freudenthal, 1995, p.111)), Balme in many respects ignores what Freudenthal takes to be a crucial analogy between vital or generative heat and the fifth celestial element.

Freudenthal himself takes a third approach that cuts down the center of the Solmsen-Balme dichotomy. While he wants to ground his interpretation of the connate *pneuma* in the biology, he is keen to maintain the distinction between vital and non-vital heat. To begin with, he examines the process of *pneumatization* in general. This process is what happens when the hot is applied to the moist. This results in little bubbles of hot air (*pneuma*) within the moist liquid. In the case of boiling water, we see these bubbles come together, rise to the surface, and separate out of the water completely.

However, boiling water is not Aristotle's model for the formation of *pneuma* within the body. Instead, Freudenthal suggests, Aristotle took as his model the heating of milk (Freudenthal, 1995, pp.121-122). In milk as in water, small bubbles of hot air form when the liquid is heated. However, in milk these *pneuma* neither clump together within nor separate off from the milk. And so it is with the blood, Freudenthal thinks. The connate *pneuma* are the result of the action of vital heat upon the blood of a living creature.

But recall that Freudenthal wants to make much of the analogy between vital heat in animals and the celestial, supralunary element. These both share the capacity to inform matter, but they are *not* identical, Freudenthal maintains. The main reason for this is that the celestial element (*aither* or *thermon*) is not a form of heat, much less hot itself. Rather, it is by virtue of its *function* (informing matter and generating new beings) that the *aither* is analogous to the (sublunar) vital heat.

So much for the formation of connate *pneuma*; now on to their function. According to Freudenthal, the function of the connate *pneuma* is to convey the vital heat throughout the body. For Aristotle, the bloodstream goes everywhere in the body. And as discussed above, Aristotle envisions the bloodstream and the blood distributing the soul throughout the body. And now we have a more nuanced account of how that occurs. The soul[4] is equated with vital heat, but vital heat itself has no material component. However, when vital heat acts upon the blood, it forms connate *pneuma* in the blood, which in turn act as a substrate for the vital heat. The blood carries the material *pneuma* through the body, bringing the immaterial vital heat (i.e., the soul) to each part of the body.

5 The Issue

It is obvious that both the parent animal and its fully-formed offspring have the form of that animal. And moreover, they are of the same kind[5] as their (male) parent. So the question is how does the form get from the parent to the offspring.

It really comes down to what we think it is that the male semen imparts to the female matter. Here I see three options:

1. The semen has the form in it, actual and whole.
2. The semen has the form within in it, but it is form only potentially, and not actually.
3. The semen has something else within it that is not a potential form, but is something that will give rise to form when the semen combines with the menses.

What about (1), where the semen contains the actual form? We can probably dispense with this thesis relatively quickly. The most obvious reason for this is that the matter of the semen is not human matter. While it obviously is produced by a human being, it is not human matter in

[4] At least the nutritive soul. I am not concerned about the other types of soul, as the current paper focuses on merely growth and reproduction, both of which are concerned with the nutritive soul.

[5] I am discounting the case of hybrids, as in the case of a mule produced from a horse father and donkey mother. But even in this case, Aristotle seems to hold the view that the form that the mule has is that of its equine sire, albeit incompletely and degenerately expressed due to the unsuitability of the matter provided by its mother (see also *PA* I 1, 641^b39 ff.).

the sense of having the passive power to become a human being. If it did, then there would be no need for the female in sexual reproduction; men could produce children solely from their semen.

But what remains is the task of distinguishing what the difference is between (2), having form potentially, and (3), having some sort of form proxy without having the form. This is quite a subtle distinction. To our modern way of thinking, these might seem to easily collapse into one another, especially if we think of the form proxies as something having the potential to create or become forms themselves. But I will argue that for Aristotle, the notions of potential form and form proxy are two different ideas.

Because "the seed is in potentiality" (*PA* I 1, 641^b36), one of the keys to untangling this issue is understanding Aristotle's notion of potentiality. One place where he discusses potentiality in fairly explicit connection to the the soul is in *De Anima* II 5. There he marks a distinction between "different senses in which things can be said to be potential or actual" (*DA* II 5, $417^a21 - 22$). Aristotle brings this distinction out in an example of the different sorts of potentiality we can mean when we say that "man is a knower". These two senses are first, that the man has the potential to come to know things through repeated instruction, and second, that the man has within him latent knowledge (of grammar, say). That is, he has the potential to use that knowledge, but it is not always active within him.

These two senses of potential may be roughly mapped onto the form in potential and form proxy division introduced above. The second sense, the "latency" reading, as it were, corresponds broadly to the form in potential interpretation. Likewise, the first sense, the "capacity" reading, corresponds broadly with the form proxy idea. However, these are not exact correspondences, especially not the second.

It seems to me a more proper analogy to compare the newly combined semen and menses to the "capacity" potential reading. It is not that there is latent form in the fetation. Instead, the fetation has just begun the process of growing and shaping itself into a complete animal. And so the fetation's "potential for form" is not the "latency" sort of potential, whereby it can bring that form into actuality the way a man who knows grammar can call upon that latent knowledge. Rather it is more like Aristotle's student of grammar, who has the potential (in the "capacity" sense of the

word) to know grammar, but only comes to *actually* know grammar through instruction[6]. Here the fetation is not being instructed by some outside agent, but by something within itself; namely, its internally contained efficient cause.

6 Potential Answers

Code (1987) makes an explicit appeal to the different levels of potentiality that both form and matter can exist at. He is forced to this view because he finds that "Aristotle insists that the matter and the form must both pre-exist" the being that is made up of that form and matter pairing (Code, 1987, p.56). This gets around the proscription against free-floating forms by merely prohibiting the existence of such forms at a level of full potentiality. However, the form of a new creature can (and indeed must) exist at some lower level of potentiality before that creature is generated. It seems that Code is adopting some version of the "latency" sense of potential discussed above.

The semen and the menses are an active-passive pair according to Aristotle's principle of $\kappa\acute{\iota}\nu\eta\sigma\iota\varsigma$ (*kinesis*). The semen is the mover and the menses are the moved. The active power or $\delta\acute{\upsilon}\nu\alpha\mu\iota\varsigma$ (*dunamis*) that is conveyed in the semen by vital heat is transferred to the menses. Thus the menses now contains both the active and passive kinetic principles (i.e., it contains both the mover and the moved). But still, the active power is not part of the menses *per se*. Instead what occurs is that the "vital heat, by congealing and coagulating portions of the menstrual fluid, forms a heart" (Code, 1987, p.57). The menses have become a rudimentary fetus, also known as a "fetation". It is now an independent pairing of matter and form, and because it is possessed of a heart, it now contains its own "active causal principle responsible for its own natural development into a complete animal" (Code, 1987, p.58).

"The crucial idea here is that the $\delta\acute{\upsilon}\nu\alpha\mu\iota\varsigma$ in the male semen is such that (1) embryological development is the incomplete actuality of that $\delta\acute{\upsilon}\nu\alpha\mu\iota\varsigma$ and (2) the soul of the animal is the

[6]As an aside: This is related, but distinct from, the ways in which linguists and cognitive scientists speak of "knowing grammar". Where Aristotle speaks of a student learning grammar through instruction, I think what he has in mind is what a modern linguist would think of as acquiring a grammar or language. He is not intending to mark a distinction between conscious and non-conscious knowledge; that is a thoroughly modern distinction.

complete actuality of that same *δύναμις*" (Code, 1987, p.56). That is, there is a potential power in the semen and in the developing embryo, which only becomes fully actualized in the final creature. Code admits that this is a controversial claim (Code, 1987, p.56 n.19); the *δύναμις* may be an ability or power that is only in the semen, and is destroyed before making it into the animal itself. That is, it is also possible that the potential *δύναμις* should be interpreted as the "capacity" sort of potential.

Code claims that "for Aristotle, the soul of a living thing is its efficient cause" (Code, 1987, p.51). While it is true that the soul of a living creature is at least partly constituted by the motions of an efficient cause, that cannot be the whole of it. For the motions characteristic of living creatures are intrinsically constrained by some ratio or *logos* (Bradie and Miller, 1982, p.138; see also *GA* II 1, $740^b32 - 33$). This is to be contrasted with the motions of fire, a purely efficient cause: "the growth of fire goes on without limit so long as there is a supply of fuel" (*DA* II 4, 416^a15).

Two alternatives present themselves here. One is to claim that Aristotle's notion of soul contains not just an efficient cause that moves the animal, but a formal cause that constrains those movements in the appropriate manner for an animal of its kind. The other alternative is to adopt a "thick" notion of efficient cause, whereby the efficient cause can contain its own limiting *logos*. Another way of putting this same question is to wonder whether we should assimilate formal and efficient causes in the case of the generation of animals.

Freudenthal (1995) adopts the first of these positions, and Bradie and Miller (1982) also adopt a variation of the first position. Bradie and Miller, though, see a final cause instead of a formal cause as being operative in the semen. That is, the constraint on the movements in the blood, semen, and so forth, is teleological in nature. For present purposes, though, this appears to be a relatively minor distinction. Aristotle himself admits that in some cases the formal and final causes can in some instances come to the same thing: "the last three often coincide; for the what [formal cause] and that for the sake of which [final cause] are one, while the primary source of motion [efficient cause] is the same in species as these" (*Ph.* II 7, 198^a25). This line also suggests that sometimes the efficient cause is in some way the same as the (combined) formal and final causes. Yet it is not completely assimilated; it is merely "the same in species" as the first two, and not identical with

them.

Code (1987), however, appears to be assimilating *all three* of these causes into one. He equates the soul with the efficient cause, and this is the only cause that he speaks of in his discussion of the transfer of soul from the father to the child. Yet as Freudenthal (1995) and others have pointed out, an efficient cause alone is not enough to be the cause of the well-regulated growth of natural creatures. So it seems obvious that there must be something more packed into Code's notion of efficient cause than the efficient cause that is active in, say, the building of a house or the baking of a loaf of bread.

One thing that I think may be going on here is that Code is conflating two related but still distinct ways of viewing living things. Discussion of the soul as the cause of motion in an animal is a psychological way of putting things, whereas discussion of the efficient (and other) causes is a physical or biological way of putting things.

There is no disputing that the semen contains some sort of active power, which works as an efficient cause on the matter in the female menses. But of course this does not lead directly to the semen containing the form. When discussing the the form of the animal, we need to make some reference to either the final or formal cause. Thus the question of whether the form of the animal is in the semen becomes the question of whether there is a final or formal cause *in* the semen itself.

So far we have been discussing the source and role of nutritive soul in the generation of animals. As we have seen Freudenthal (1995) equates nutritive soul with vital heat, and this soul (carried on the substrate of connate *pneuma*) is conveyed in the semen and "informs" the matter of the female menses. The vital heat is a combination of an efficient cause and a formal cause; the formal cause imposes an order and a ratio on the movements of the efficient cause, in order that the substances concocted of the efficient causes should accord to the proper *logos* for that animal.

In *GA* II 4, Aristotle observes that while all females produce generative residues, not all males do. His reasoning is that "while it is necessary for the female to provide a body and a material mass, it is not necessary for the male, because it is not within what is produced that the tools or the maker must exist" ($738^b22 - 25$).

One reading of this is that while the semen is a good way of conveying the soul from the father

to the offspring, it is not the only way. In the animals that do not produce semen, the father must convey his motions more directly into the female residue. And "just as those which do emit [semen] fashion by the movement in the semen [...] the material provided by the female, so do the animals in question [...] exert the same formative power by the movement within themselves in that part from which the semen is [would be] secreted"[7] (*GA* II 4, $738^b11 - 15$)

This gives us reason to think of the semen as a proxy for the movements of the male. Thus in animals (such as humans) that produce semen, sex can be a much more approximate matter. The male simply has to emit his semen into the female, and the semen does the actual work of conveying the movements of the male to the female generative residue (the menses). Thus, I think, this passage is support for the "form proxy" view of what is conveyed by the semen. The semen contains connate *pneuma* as the physical substrate for the vital heat, which on this view we can think of as merely echoing the father's bodily movements. So on this view, all the semen actually contains is an efficient cause. There is no formal cause actually in the semen, except in the sense that the movements of its efficient cause, being mere echoes of the father's movements, are already constrained.

7 Conclusion

To sum up, here then are the three causes that are involved in producing a new animal:

1. Efficient cause: movements for an X
2. Material cause: matter for an X
3. Formal cause: what sort of X are we making?

It is obvious that the material cause comes form the mother, and the efficient cause comes from the father. On Freudenthal's account, the formal cause is also directly transmitted from the father, since it is part of the vital heat that is in the semen. On Code's view, the semen conveys the

[7]The latter half of this sentence makes much more sense in the subjunctive; i.e. if it is read as "from which the semen *would be* secreted", since Aristotle here is discussing animals which do not in fact emit semen. I am not sure, though, whether this would be accurate to the original text or not.

efficient cause alone, but this efficient cause makes up the soul of the animal. While Code does not explicitly address this issue, there must be more to the efficient cause than just movements, if it is to truly participate in the generation of a living creature. The efficient cause must be self-limiting in some way.

This brings us to the last view I outlined above; call it the "echo" view of the transmission of form. Here again we have a self-limiting efficient cause. But unlike Code's account, this is not because the efficient cause is the soul of the creature, which is actively regulating its movements. Instead, the limits are "pre-programmed" into the efficient cause in the semen by the movements of the father. While his movements *are* guided by his soul, the movements in the semen are not. On this account, soul only comes into the picture once the heart of the fetation is formed.

I think there is something to be said for this latter "form proxy" model. For one thing, a clear analogy can be made to the case of the generation of artifacts, which is an important parallelism in Aristotelian thinking. Aristotle says that "it is not within what is produced that the tools or the maker must exist" (*GA* II 4, $738^b24 - 25$). One way I read this is that the offspring ("what is produced") need not receive anything directly from the father ("the maker"), nor from his semen ("the tools"). A baker has in mind the form of a loaf of bread, but though that form guides his movements in mixing and kneading the dough, and in setting the oven to the right temperature and baking the loaf for the proper time, there is nothing of him that is directly conveyed to the resulting bread.

Thus when Aristotle speaks of the form existing in potential in the seed or semen (*PA* I 1), I take him to be using the "capacity" notion of potential. In the right conditions, the semen has the power to transform matter into something with a certain form. But this is not the same as the semen having the form, and under the right conditions "giving" this form to the matter.

8 Coda: Aristotle and DNA

It is sometimes tempting to backport current philosophical or scientific notions to Aristotle's theories, or alternatively, read Aristotle as anticipating current theories in these fields. His account of the generation of animals is not immune to this phenomenon. For instance, in the conclusion of

their paper, Bradie and Miller (1982) speculate on the connections and implications that Aristotle's theory of vital heat and connate *pneuma* have for modern biology.

In their account of Aristotelian reproduction, they separate out the principle that biological processes such as growth and sexual reproduction occur according to some guiding rules on instructions within the organism itself from the specific physical implementation of that principle (i.e., the theory of vital heat). And while acknowledging that the physical account that Aristotle gives is quite remote from the way we understand biology today, they propose that the principle of organism-internal rules or instructions "has been vindicated by modern biology" (Bradie and Miller, 1982, p.143). What they have in mind is DNA, which while being a completely new physical implementation of the principle of self-regulation, nonetheless highlights the correctness of Aristotle's biology in the abstract.

We should be cautious here, though. An important tenet of modern biology and genetics is that the instructions for the creation of the offspring come from *both* parents equally, and not solely from the male, as is the case in Aristotle's account.

While I am unsure about making a wholesale connection between Aristotle's biology and modern genetics, there is an important biological principle that Aristotle does appear to be the first to really notice. That is the principle that "man begets man" ; that is, that species reproduce according to kind, and that species is an important way of categorizing the natural world[8]. Related to this is the point that species reproduce by kind according to something within themselves, and that perpetuation of a species requires no agency outside of the individuals of that species. As Freudenthal puts it, "the *phusis* of each species [...] is *within* each and every (male) individual of that species" (Freudenthal, 1995, p.37).

[8]We may also note that Aristotle's view of specieshood is not as fixed as some other ancient writers, and that given his acceptance of hybrids and such, he might have been amenable to the notion of evolution of species (Balme, 1992, p.97). But again I caution against trying to backport any sort of Darwinian evolutionary theory onto Aristotle's biology; this is merely an observation that Aristotle's biology seems to be *compatible* with the idea of "descent with modification".

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Abbreviations

GA Generation of Animals
PA Parts of Animals
DA De Anima
Ph. Physics