

CHAPTER 23: *GENERATION OF ANIMALS**

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The place of GA in Aristotle's philosophy

The best way to understand the place of *Generation of Animals* in Aristotle's philosophy is to consider the way Aristotle himself envisions the proper organisation of the study of living things. According to *Parts of Animals* I.1, biology starts by collecting the phenomena concerning each kind and then goes on to study its causes. The three main biological works—*HA*, *PA*, *GA*—seem to be organised in accordance with this. *HA* studies the differentiae of animals, while *PA* and *GA* provide their causal explanations. In this way *PA* and *GA* follow on the results of *HA* (though see Balme 1987; cf. Lennox 1996). The relative order of *PA* and *GA* can also be understood in terms of the methodological recommendations of *PA* I.1. At 640a10-19 Aristotle tells us that the causal story must begin with the animal as it exist in actuality (the mature organism) and then go on to consider how it comes into being. In this way causal explanations proceed from the causes of *being* an animal (*PA*) to the causes of *becoming* one (*GA*); for coming-to-be is for the sake of being rather than vice versa (*PA* I.1, 640a10-32; *GA* V.1, 778b2-11; cf. Lennox 2001a, xi).

The four causes of animal generation can be summarised as follows. The mother and father represent the material and efficient causes, respectively. The mother provides the matter out of which the embryo is formed, while the father provides the agency that informs that material and triggers its development. The formal cause is the definition of the animal's substantial being (*GA* I.1, 715a4: *ho logos tês ousias*). The final cause is the adult form, which is the end for the sake of which development takes place. I shall return to this four-fold account at the end of the chapter once we have a better understanding of Aristotle's project in *GA*.

Male and Female as archai

Aristotle's investigation into animal generation begins from the observation that offspring come into being from the union of animals of the same kind and that male and female are the "starting-points" (*archai*) of this change:

Of the generation of animals, we must discuss various questions case by case in the order that they arise, and we must connect our discussion to what has been said. For, as we said above, the male and female may be put down first and foremost as starting-points of generation, the male as possessing the efficient cause of generation, the female as possessing the material cause. The most convincing proof of this [sc. that male and female are starting-points of

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generation] is drawn from considering how and whence sperma¹ comes into being. For although the things which are generated naturally come from this, we must not fail to notice how this comes to be from the female and the male. For it is because this sort of part is secreted from the two sexes (the secretion taking place in them and from them) that they are starting-points of generation. (*GA* I.2, 716a4-13)

(That the male and female are starting-points of generation was already established in *GA* I.1 by observing that some animals come into being through sexual reproduction and that “these kinds possess sexes” (715a17-29). The idea that the male is the efficient cause while the female is the material cause is Aristotle’s own theory, which he develops over the course of the first two books (see below).)

This passage is relevant for understanding the general structure of Book I. For example, the statement that male and female are *archai* of generation is meant to lead to a discussion about the nature of sperma. According to common opinion (*endoxa*), sperma is the starting-point of generation since the development of the individual begins from it (compare *PA* II.7, 653b18-19). Aristotle’s statement is meant to correct this. Although sperma is in a sense the beginning of the change, natural generation must ultimately be traced back to the parents since sperma comes into being from them. Thus, by studying how sperma is produced and whence it comes (the project of the second half of Book I) we will be in a better position to see that male and female are the ultimate principles of generation. This in turn is necessary for showing that natural generation is a cyclical change and therefore eternal (*GC* II.11), and that it is through reproduction that individuals are able to achieve a kind of immortality and thereby partake in the divine (*GA* II.1, *An* II.4).²

The Nature of Sperma

Of the two main topics examined in Book I—the instrumental parts connected with reproduction and the nature of sperma—the account of sperma is more important for the argument of the *GA*.³ The best way to understand Aristotle’s project here is to see it as an attempt to formulate a series of definitions progressing towards a full scientific account of sperma which will be among the first principles of embryology (Bolton 1987). Beginning from a pre-scientific understanding of sperma as “the sort of thing from which naturally generated organisms originally come to be” (724a18-20), Aristotle goes on to provide a series of progressively refined scientific accounts:

- (1) Sperma is a certain kind of residue (725a3-4; cf. *An. Post.* II.8, 93a21-8).
- (2) Sperma is a useful residue (725a11).

(3) Sperma is a useful residue of ultimate nutriment (725a12-13, 726a26-9).

While (2) exhibits both the genus (“residue”) and differentia (“useful”), (3) reveals a further feature of sperma that is said to be explanatory of certain others. For example, being a residue of ultimate nutriment (which in animals is blood or its analogue) is supposed to explain why offspring resemble their parents in species (725a26-7). For by “ultimate nutriment” Aristotle means “that which gets distributed to each part of the body and out of which they are directly formed” (725a11-13) and “that whose nature is to go to the whole body” (725a21-7).

When used in this generic sense, “sperma” thus refers to a useful residue of ultimate nutriment from which naturally generated organisms originally come into being.⁴ In animals this account is further divisible into an account of male sperma and female sperma according to the different senses of “from which” specified in the definition (cf. 724b4-7). The offspring comes “from” male sperma *as mover*, in the way that the house comes “from” the carpenter, while it comes “from” female sperma *as matter*, in the way that the house comes into being “from” bricks.⁵ Aristotle develops this theory in the closing chapters of Book I and into Book II. There we learn that just as none of the matter for the house comes from the carpenter’s body, so too semen contributes nothing material to the construction of the offspring (*GA* I.21). Rather, it makes its contribution by means of a certain *dunamis* (*GA* II.1). This *dunamis* is the power to form the embryo, which Aristotle compares to rennet’s power to curdle milk. In both substances vital heat is the active ingredient which is the seat of the *dunamis* (*GA* I.20, 729a9-13, b26-29; cf. II.4, 739b21-33; IV.4, 771b21-4, 772a8-30). We also learn that female sperma lacks this *dunamis* because it lacks the same level of vital heat as semen. The female is colder than the male and so is unable to fully concoct her sperma. As such menstrual blood is colder, more fluid, and greater in bulk than semen (726b31-727a2, 738a12-15, a34-b2, 765b16-35; cf. *Meteorologica* IV.2, 380a4-9).

The Transmission of Soul: GA II.3

Another question posed by the *GA* is how animal souls are transmitted in reproduction. According to the traditional interpretation, the father transmits all faculties of soul to the offspring using his semen as a vehicle. This was certainly Aristotle’s initial position. Thus, early in Book II he says:

As to the question of whether or not semen possesses soul, the same argument concerning the parts of the body also applies here. For no soul will be present anywhere except in that of which it is the soul and no part of the body will be such except homonymously unless it partakes of soul (just like the ‘eye’ of a

corpse). Hence it is clear that semen contains soul and is potentially <the parts of the body>. (*GA* II.1, 735a5-12)

However, Aristotle was eventually forced to reconsider this view in light of a puzzle arising in *GA* II.3.

GA II.3 opens with the following question: What happens to the physical part of the semen once it has performed its function? On the one hand, Aristotle argues that the semen makes its contribution by means of a *dunamis* and not by supplying matter for the offspring's body (736a25-8). So the physical part of the semen does not remain in the finished product in the way that the bricks remain in the finished house. (Compare the analogy with the carpenter at *GA* I.21, 729b14-20; I.22, 730b8-23.) And yet, on the other hand, we do not find the semen inside the female after conception or being discharged from her at any point (737a13-15). So if the semen is not used up in the construction of the offspring's body, what happens to it?

Aristotle's worry is that his solution to this puzzle—the semen evaporates—is inconsistent with his earlier view that semen is the vehicle for transmitting soul to the offspring. The key here is the idea, stated in the passage quoted above, that no soul can be present anywhere except in that of which it is the soul (compare *GA* II.3, 736b21-6). Something like this lies behind the requirement at *GA* II.3, 736b13-16 that a thing must first possess soul potentially before it possesses it actually. To possess a soul *actually* is to possess organs with the capacity to perform certain functions (since “soul” is the first-actuality of the living body; cf. *An* II.1, 412b11-15, 412b18-22, 413a1). Whatever possesses soul *potentially*, then, must be the sort of material that is capable of developing the right structures (cf. *An* II.5, 417a26-7). So if semen possess soul potentially, it must be the sort of thing which is capable of developing functioning organs: it must be potentially “that of which it is the soul”.

Now Aristotle has already concluded in Book I that animal sperma is potentially the parts of the body in virtue of being a residue of blood. Since semen is a form of sperma, it would appear to be a suitable candidate for conveying soul. As Aristotle says, “the semen of the hand or the face or the whole body is a hand or a face or the whole body, though in an undifferentiated way; in other words, it is potentially what each of those is actually” (*GA* I.19, 726b17-20). The problem arises because Aristotle insists that male semen does not become any of those parts in actuality; the parts of the offspring are not formed from semen as matter but only as moving cause. Aristotle repeats this at the start of *GA* II.3: “The semen which is introduced into the female is not an ingredient in the thing which is formed but performs its function simply by means of the *dunamis* it contains.” So why is this a problem for conveying soul?

For Aristotle, “soul” refers to a set of life-capacities possessed by the body (cf. *An* II.1, 412b18-22: “if the eye were an organism, sight would be its soul”). This is why soul cannot exist apart from that of which it is the soul: capacities cannot exist apart from the things of which they are capacities.⁶ Sight cannot exist in separation from the eye, nor the capacity to walk apart from legs (*GA* II.3, 736b22-4). It follows from this that an Aristotelian soul cannot exist before its corresponding body has been formed *or after* that body has been destroyed.⁷ Given the inseparability of soul and body (function and structure), there are only two ways that semen could serve as a vehicle for transmitting soul to the offspring.

One is for the semen to carry another body inside itself which acts as the material substratum for the soul transmitted. For example, semen could transmit sight by carrying eyes. However, Aristotle has already rejected this preformationist alternative in *GA* II.1 (733b31-734b4). The parts of the offspring do not come into the female already preformed inside the father’s semen.⁸ The other way would be if the semen itself were the material substratum of the soul it carried, that is, if the physical part of the semen stood to that soul as matter to form. This was Aristotle’s initial position in *GA* II.1 when he said that semen contains soul and is potentially the parts of the body. If the semen then became those parts in actuality, it would come to possess soul in actuality as they developed from it. But that is not Aristotle’s position. The parts of the offspring develop out of menstrual blood *not* semen. After the semen forms the embryo and triggers its development it evaporates and its bodily substance is destroyed (737a11-17).

Herein lies the problem. Since Aristotelian souls are inseparable from the bodies of which they are souls, when the semen perishes any soul it possesses must perish along with it. Hence semen cannot be a vehicle for transmitting soul from the father to the embryo:

Clearly those capacities of soul whose activity is bodily cannot be present anywhere without a physical body; for example, the capacity to walk cannot be present anywhere without feet. And this also rules out the possibility of those capacities of soul entering <the embryo> from without (since it is impossible for them to enter on their own) as well as their entering by being transmitted in some body [namely semen]. For semen is a residue of nutriment that undergoes a change.⁹ (*GA* II.3, 736b21-5)

The complicated argument that runs through most of *GA* II.3 is an attempt to head-off this problem by providing a new account of how animal souls are reproduced. At 736b16-21 Aristotle considers several alternatives. The one he opts for is that some faculties of soul pre-exist in the embryo while others come into being as the embryo develops (without having been

carried in by the semen). For example, the nutritive soul is already present in the embryo even before the semen makes its contribution (736a34-6, b8-13).¹⁰ And it is “as they develop” that animals come to acquire sensory soul (736b1-2). Only intellectual soul is left with the possibility of “entering from without” (*thurathen*), since its activity is not associated with any bodily organ (736b26-30, 737a8-11). However, this idea is left obscure and undeveloped.

Reproductive Hylomorphism

Throughout the course of the *GA* Aristotle develops a thesis about the distinctive contributions of each sex to the process of generation, which I shall call “reproductive hylomorphism”. In its most general formulation, the thesis states that the male contributes the form (*eidōs*) while the female contributes the matter (*hylē*).¹¹ At first glance Aristotle’s reproductive hylomorphism seems straightforward. The female provides a quantity of unformed matter which is given shape and form by the semen just as the sculptor forms the unsculpted bronze into a statue. But this characterisation of the male and female contributions provides an inadequate picture of Aristotle’s theory. While saying the mother provides the matter certainly does mean her contribution is used to make the parts of the offspring (and so in this sense is analogous to unsculpted bronze),¹² it is far from obvious what it means to say the father provides “the form”.

A careful reading of the *GA* reveals two ways in which the father can be said to provide “form”. According to the first formulation (the version that dominates Book I), providing form does not involve the formation of any complex structures with soul-functions. Rather, the semen is said to provide form to menstrual fluid in the way that rennet forms curds out of milk (*GA* I.20, 729a10-14). The heat in the father’s semen acts on the menstrual fluid, drawing in the bits of spermatid residue contained in it and fusing them together into one solid mass (cf. *GA* II.4, 739b21ff.; IV.4, 771b22-24). The product of this event is not a fully formed organism but an amorphous seed—the zygote—which is the immediate product of fertilisation.¹³ Once this seed has been formed, the heat in the semen triggers its development in the way that one triggers the movements of an automaton (*GA* II.5, 741b7-9).

It is important to note that this first formulation of the matter-form thesis does not pick out the male’s exclusive contribution to the process. At *GA* I.21, 730a29-30 the male is said to contribute the principle that initiates change and determines the menstrual fluid (i.e. gives it form). Aristotle then suggests that in some species the female might be capable of supplying this principle herself, which he confirms in *GA* II.5 (cf. III.7, 757b12ff.). However, in this context Aristotle is only talking about the basic act of forming the embryo (which he likens to forming curds in milk) and triggering its development.

The second version of Aristotle's hylomorphic model is formulated in *GA* II.4. This is the more important formulation. Here the form that the father is said to provide is the offspring's *soul*, while the mother is said to provide its *body* (738b25-6). Yet, when we turn to *GA* II.5 we discover that this soul/body hylomorphism does not actually apply to the offspring's entire soul but only a part of it. In the final analysis, what the male *alone* is said to provide is the offspring's sensory soul. This is what Aristotle ultimately means when he says that the father's exclusive contribution to the generation of an animal is its "form". For the sensory soul is the form of an animal in the strict sense. It is the property that makes a living thing an *animal*.

Aristotle also reveals in *GA* II.5 that the mother's contribution is not confined to providing the offspring's body; she also provides part of its soul. In some species the female can generate embryos capable of (minimal) growth without being fertilised by the male, a phenomenon known as parthenogenesis. Parthenogenesis plays a significant role in the argument of the *GA*, since it allows Aristotle to isolate the unique contribution of the male parent. Aristotle observed that unfertilised "wind-eggs" never develop to the point where they begin to form sense organs, which (he thinks) shows that the father's contribution must be responsible for the development of the sensory system. The fact that wind-eggs develop at all, however, shows that the nutritive power of soul comes from the female. For those embryos grow (and decay) without any contribution from the male, but simply in virtue of the nutritive soul acquired from the female.¹⁴

There is one final issue to address concerning the semen's role in the process of generation. In general, the father's semen is directly responsible for three principle events: forming the embryo out of menstrual blood; constructing the embryonic heart (cf. 735a12-26); and triggering the development of the remaining parts. It is a common misconception that Aristotle thought the father's semen fashions the offspring in its entirety (e.g. Furth 1988, 119). This generally results from a failure to consider how the argument develops past Book I. Throughout Book II, for example, Aristotle repeatedly emphasises that the proximate cause of generation is the offspring's own nature, which co-ordinates the sequence of changes (triggered by the semen) through its newly constructed heart. This is the main conclusion of the closing argument of *GA* II.1. There Aristotle argues that because the heart is the first part to be formed it must contain a generative principle. For at that point the embryo must be able to take over for the semen and build the rest of its body. This is also the point of the "rational argument" at *GA* II.4, 740a5-24. Aristotle again argues that because the heart is formed before the other parts, it must contain "the principle from which the subsequent ordering (*diakosmêsis*) of the animal's body derives". For once this part has been formed the embryo must be able to "manage itself"

(*hautō diokein*), just as the son who has been sent away from his father must be able to set up and manage his own household.¹⁵ By locating the source of growth and development in the embryonic heart Aristotle was able to bring the theory of the *GA* in line with the *Physics*, which defines “natural” changes as those deriving from a principle in the thing itself *qua* itself (*Physics* II.1).

Aristotle eventually identifies the embryo’s generative nature with its soul, which is said to be “the active power” that forms the parts of the body in the beginning:

For, since the material out of which the organism grows and that out of which it is originally constructed are the same, the active power is also identical with the one which is operative in the beginning (but greater than it). If, then, this is the nutritive soul, it is also that which generates. And this is the nature of each organism, being present in all plants and animals alike. (*GA* II.4, 740b35-741a2; cf. *An* II.4)

Here we encounter a problem. Aristotle says the offspring’s nutritive soul is the agent that constructs the parts of the body, including the parts of the sensory system (see note 15). Yet he goes on to argue in *GA* II.5 that the nutritive soul comes from the mother *and* that the father alone provides the sensory soul. How are these two theses reconciled?

It is unlikely that Aristotle means to say that the mother’s contribution is responsible for constructing the sense organs while the semen implants sensory soul in them. Aristotelian souls are not the sorts of things that are capable of being implanted in bodily organs from without (except perhaps intellectual soul). Soul is not an extra ingredient added to the organ over-and-above its structure; once there is a properly constructed organ it straightaway possess the corresponding soul-function in virtue of its structure.¹⁶ So if the nutritive soul is responsible for constructing the parts of the body, including the sensory parts, then *all* faculties of soul would be traced to the mother’s contribution. And this contradicts the hylomorphism of the *GA*.

One solution to this puzzle is to distinguish the “nutritive soul” that *GA* II.4 identifies with the offspring’s generative nature from the “nutritive soul” that *GA* II.5 says comes from the mother. The former is the power to construct the parts of the body in the beginning, which *DA* II.4 calls “the generative soul”. The latter is the general capacity of a living thing to process nutriment and to increase and maintain its size. The mother supplies nutritive soul only in this minimal sense (basic metabolic functions). On this reading each parent will contribute part of the generative soul. The mother contributes the part that governs the development of the metabolic system, while the father contributes the part that governs the development of the sensory system (though see further below).¹⁷ It is this latter part which is missing from the generative souls of

those wind-eggs that are produced by females alone. And this is why their development stops at the point where fertilised embryos begin to develop sense organs.

Inheritance

One of the most interesting aspects of the *GA* is the theory of inheritance in *GA* IV.3 (Aristotle's central account of inheritance comes at *GA* IV.3, 767a36-768b10). It has not been well understood by commentators and relatively little has actually been written about it. What I shall offer here is only a brief sketch of the theory (for a more detailed discussion of this see Henry 2006a).

In a key passage at *GA* 767b35-768a2 Aristotle sets out the basic mechanism underlying the phenomenon of inheritance:

(T1) I speak of each *dunamis* in the following sense. The generator [*to gennôn*] is not only a male but also a particular sort of male, e.g. a Coriscus or a Socrates,¹⁸ and it is not only a Coriscus but also a human being. And it is in this sense that, of the characteristics that belong to the generator insofar as it is capable of generating [*katho gennêtikon*] and not incidentally [*kata sumbebêkos*] (e.g. if it is a scholar or someone's neighbour), some belong to it more closely while others more remotely. ...So, there are *kinêseis* present in the seeds of animals derived from the *dunameis* of all of these sorts of things [sc. male, Socrates, human], and in potentiality even those of its ancestors, although those of the individual are always closer.

This passage tells us two important things about Aristotle's theory of inheritance. First, it draws a distinction between the *heritable* properties of an individual (those that belong to the generator *katho gennêtikon*) and what we might call its *genetically incidental* properties (those that are *kata sumbebêkos*). The examples of genetically incidental properties are being a good scholar and being someone's neighbour. These properties are incidental to the generator *qua* generator precisely because they are not passed on in the act of reproduction; they are not heritable. Second, it sets out the mechanism that explains the transmission of an organism's heritable traits. The two central components of this mechanism are the "*kinêseis*", which are said to be present in the parent's reproductive material, and the "*dunameis*" from which those *kinêseis* are derived. The main interpretive difficulty that arises in connection with *GA* IV.3 is how to understand the mechanism in T1. Specifically, what are the *kinêseis* and *dunameis* supposed to be? Once we have come to understand how the mechanism works, we will not only be in a better position to understand Aristotle's theory of inheritance itself but more generally how he thinks biological form is passed on from one generation to another. For throughout the discussion Aristotle

makes it clear that the same mechanism that explains resemblance in individual characteristics also explains resemblance in species-level properties (767b24-6, 768a13-14, 768b10-15).

Aristotle's hereditary concept of a *dunamis* here is not that different from his metaphysical concept of *dunamis* (see esp. *Metaphysics* □ 1-6). According to *Metaphysics* Θ1, a *dunamis* is a power or capacity for acting or being acted upon. Thus it is reasonable to suppose that the *dunamis* in our passage refer to specific developmental capacities (cf. Morsink 1982, 134-5). This hereditary concept of a *dunamis* is meant to provide the ontological basis for the distinction Aristotle draws in our passage between features that belong to an organism *katho gennētikon* and those that are *kata sumbebēkos*. Unlike genetically incidental traits, each heritable feature of an organism can be traced to a corresponding *dunamis* in its generative nature, which is a capacity for the formation of just that trait. In this way *GA* 767b23-768a2 can be seen as an attempt to isolate the more precise (efficient) causes of reproduction. The *dunamis* are the causal entities behind the heritable features enumerated in that passage.¹⁹

The *kinēseis* (which are said to be present in the reproductive materials of organisms) function as the vehicles for transmitting these *dunamis* in the act of reproduction (see Witt 1985, 56 n. 26; Henry 2006a).²⁰ For lack of a better word I will simply translate *kinēsis* here as “movement”. This need not imply that Aristotle thinks there are literal motions or changes occurring in the organism's sperma. He could be thinking of local motions (e.g. vibrations or waves) that somehow encode the characteristics of the parent's body. However, what *GA* IV.3 seems to provide is an explanatory framework for giving an account of inheritance at a more abstract level. As such, we should not expect the concepts being deployed there to be spelled out in concrete terms. If this is right, then Aristotle's spermatocentric “*kinēsis*” would be like Mendel's “factor” in that both concepts attempt to abstract away from the concrete physical basis of the vehicles of inheritance.²¹

The picture presented in T1 thus looks something like this. Socrates' semen carries a set of “movements” derived from various capacities of his generative nature, each of which is the productive source of a corresponding characteristic. For example, there will be one movement corresponding to his snub nose and another corresponding to his particular shade of eye-colour. If each of these movements “dominates” (*kratein*), then Socrates' son will come to resemble him in both these respects.

According to the traditional interpretation, Aristotle failed to assign the mother a direct contribution to inheritance. Rather, maternal resemblance simply results from the semen failing to impose the father's likeness on the matter. On this reading the mother is at best an accidental cause of maternal inheritance insofar as the semen's failure is due to the recalcitrant nature of the

material she supplies. However, when we turn to Aristotle's account of maternal inheritance we find something that does not sit well with this picture. As several commentators have noted, *GA* IV.3 introduces a set of maternal "movements" to account for resemblances to the mother's side of the family. Apparently Aristotle's idea is that, like the father, the mother contributes a set of spermatogenic movements associated with the features of her own body as well as those inherited from her ancestors. Maternal resemblance occurs whenever one of her movements dominates over the one from the father with respect to the same feature (e.g. nose shape, eye colour).

This is most explicit in a passage where Aristotle introduces the causal mechanism behind the phenomenon of atavism (resemblance to ancestors).

(T2) [Atavism occurs when] the formative movements relapse into the ones which stand closest to them. For example, if the movement of the father relapses, it passes into that of his father (the least difference) and in the second instance into that of his grandfather. Indeed in this way too, on the female side just as on the male side: the movement of the mother passes into that of her mother, and if it not into that one, then into that of her grandmother. And in the same way for the more distant ancestors. (*GA* IV.3, 768a14-21)

What T2 makes clear is that the inheritance of maternal traits is explained by movements coming from the mother *in the same way* that paternal movements explain resemblances to the father's side of the family. The most natural reading of this passage (and several like it) is to see these maternal movements as being functionally equivalent to those of her male counter-part: both serve as vehicles of inheritance. (For an alternative, though in my opinion implausible, interpretation of maternal inheritance, see Cooper 1988. For an assessment of the problem of maternal inheritance see Henry 2006b)

Aristotle's theory of inheritance itself consists of three "general suppositions" (*katholou hypotheses*):

We must grasp the general suppositions: the one stated, that among the movements present in the parents' seeds some are present in potentiality while others are present in activity; and two others, that being dominated causes displacement into the opposite <movement>, while relapsing causes a change into the movement which stands next on the blood-line. If it relapses a little, it passes into the movement which stands closer; if it relapses more, into the one farther away. (*GA* IV.3, 768b5-10)

The first supposition concerns the existence of movements in the parent's sperma (cf. 768a12-14). The other two supply the principles that govern the interactions between the paternal and

maternal movements. The outcome of these interactions will determine the pattern of inheritance for the particular offspring. By using these three general principles Aristotle was able to explain at least seven phenomena connected with inheritance (see *GA* IV.3, 767a36-b7).

Individual forms

Many scholars have suggested that Aristotle's account of inheritance has implications for how we understand his concept of form. Traditionally scholars have held that the form transmitted in the act of reproduction is the species form. According to this view, form is (a?) universal, includes only those features which are common to the species, and is shared by all members of the same kind. Those features that distinguish one member of the species from the next (e.g. eye colour in humans) are accidental properties which result from the species-form being embodied in different quantities of matter. A corollary of this is that inherited resemblances are irrelevant to the science of biology, since there cannot be scientific knowledge of what is accidental (Sharples 2005, 105).²² A second interpretation claims that the forms of particular organisms are themselves particulars (i.e. numerically distinct, non-repeatable instances) rather than universals shared by all members of the same kind (e.g. Frede and Patzig 1988; cf. Witt 1985). This is compatible with the view that form only includes features common to every member of the species, e.g. Socrates and Callias have numerically distinct human forms (for a discussion of these two positions in relation to the *Metaphysics* plus references see ch. 12 on substance). Finally, others have argued that Aristotle was committed to a much more radical notion of *individual* forms which include features below the level of species. For one of the important lessons of the *GA* is that some individual differences are part of the form that is transmitted in the act of reproduction (Balme 1987, 291-312; Cooper 1988, 32-8; Whiting 1990; Henry forthcoming).

Aristotle's remarks on inheritance in *GA* IV.3 do seem to point towards individual forms in the last sense. Consider T1 again. Aristotle tells us that what the offspring receives from its parents is a series of *dunameis*, or developmental capacities, for different parts of its body. These *dunameis* are transmitted directly from parent to child through a series of *kinêseis*, or movements, carried in the animal's sperma. Contrary to the traditional view, Aristotle extends this mechanism to include not only the transmission of those *dunameis* that belong to Socrates as a human being but also those that are distinctive of him as a particular human being (e.g. a *dunamis* for snub-nose and blue eyes).²³ Thus it seems that the heritable properties of organisms include both species- and individual-level properties: all of these features are essential to Socrates "insofar as he is capable of reproduction" (*katho gennêtikon*). It is a short step from this to the notion of individual forms. For the *dunameis* enumerated in T1 are surely parts of Socrates' *formal* nature:

they are capacities of his *generative soul*.²⁴ It follows from this that Socrates' form will be different from Callias' form insofar as his generative soul includes capacities for developing particularly Socratic (as opposed to Calliastic) features, such as a snub nose and bulging blue eyes. It is in this sense that Socrates' form is individual: Socrates' generative soul does not just include *dunameis* for parts of a human being but more specific *dunameis* for parts of a particular kind of human being, namely, a Socrates. These more specific *dunameis* (*dunameis* for resemblances that are peculiar to Socrates) are not found in Callias' generative soul.

Some have objected that this interpretation commits Aristotle to a division into subspecific types of soul (e.g. human souls divide into Socratic soul, Calliastic soul, etc.), for which there is no evidence (Witt 1985, 51). However, if the above analysis is right, then our passage gives us every reason to think that human souls do divide into Socratic souls and Calliastic souls. If the *dunameis* for those properties that Aristotle says belong to the generator *katho gennetikon* are capacities of the generative soul (and there is every reason to think they are), then a Socratic soul *is* different than a Calliastic soul.

Whether or not *GA* IV.3 does imply individual forms, Aristotle clearly thinks the phenomenon of inheritance is scientifically explicable in terms of general principles (*katholou hypotheseis*). As such, the resemblances in question cannot be accidental, since what is accidental is intractable to scientific explanation.²⁵ At the outset of *GA* IV.3 Aristotle identifies seven phenomena that he thinks an adequate account of inheritance must explain. He then tries to explain those empirical regularities by relating them to the interactions between the various entities postulated there (the *kinêseis* and the *dunameis*), while the general suppositions supply the theoretical principles that govern the behaviour of the mechanism. If this is right, then what we seem to find in *GA* IV.3 is the first real attempt to formulate a genuine science of inheritance (this insight was first noted by Morsink 1982, if perhaps for the wrong reasons). This conclusion does not sit well with the traditional view that inherited resemblances are accidental and thus irrelevant to the science of biology.

Four causes of generation

We are now in a position to set out the four causes of animal generation in more detail (this account does not apply to spontaneous generation, which is only subject to explanations in terms of material and efficient causation). According to the *GA* the mother and father represent the material and efficient causes, respectively. The mother provides the matter out of which the embryo is formed, and the father provides the agency that informs that material and triggers its development. This account is elaborated over the course of the *GA*. For example, although the embryo is originally constituted from menstrual blood, the emerging structures are built from

nutritive blood supplied through the umbilical cord. This nutriment is processed into various types of “residue” by the embryonic heart, which serve as specialised matter for different parts (*GA* II.6, 744b13ff.). A study of the material cause of animal generation would therefore include an account of these residues and how each contributes to the formation of the body.²⁶ Further, while the father is the primary efficient cause in that his semen provides the catalyst for the embryo’s development (“that whence comes the beginning of motion”), as we have seen, the offspring’s own nature is more directly responsible for the construction of its parts. This is the theory developed in the latter half of *GA* II.1 (734b20-735a26): the material supplied by the mother is formed by a series of processes (~~κίνησις~~) which are initiated by the sire (who is in actuality what that material is potentially) and then controlled by the nature of the developing embryo itself.

The formal cause of generation is the definition of the animal’s substantial being, while the final cause is the adult form, which is the goal of the process of development (*GA* V.1, 778a33-5; cf. *Metaphysics* V.4, 1015a12, *GC* II.9, 335b6-7). At the outset of the *GA* I Aristotle tells us that these two causes refer to the same thing (715a4-5).²⁷ This is plain enough, since the form specified in the account of an animal’s substantial being is also the *telos* of its natural development. Reference to this form therefore tells us what the embryo is coming to be (and therefore what it *is*) and properly identifies the series of changes as a single process of development. Since the sensory soul is the form of an animal *qua* animal, there is a strong sense in which the father can be said to contribute both the formal and final cause of animal generation (*GA* II.1, 732a4-5). And yet, insofar as the mother also provides a part of the offspring’s soul, she too can be seen as making her own formal contribution. This is especially true if the *GA* recognises individual forms, since she is directly responsible for those features of the offspring that make it look like individuals on her side of the family (Balme 1987, 292-3).

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¹ There is no suitable English translation for *sperma* and so I shall transliterate it. Aristotle uses the term for many things: (1) generically for an organism’s reproductive material (both male and female: e.g. 716a4-13); (2) specifically for male semen alone (technically *gonê*: e.g. 727b34); and (3) for the immediate product of

fertilisation (technically *kuêma*: e.g. 724b14-18, 728b34-5; cf. 731a2-4). Unless otherwise indicated or qualified, I shall use “sperma” to mean (1), the reproductive material of animals in general.

² *GA* I also fulfils two promises from the *PA*. The first is to discuss both the instrumental and uniform parts connected with generation which had not been dealt with there (cf. *GA* I.16, 721a27-30). (The “uniform parts” in question are sperma and milk, which are included among the useful fluids produced in the last stages of digestion (*PA* II.7).) The other is to discuss the hypothesis, introduced in *PA* IV.10, that the reproductive fluids are both “residues”.

³ Aristotle’s own account of sperma does not begin until *GA* I.18, 724b14. Prior to this he presents a dialectical argument against the view that sperma is composed of tiny bits of tissue drawn directly from the parts of the parent’s body, which has come to be known as “pangensis”. This was the theory held by Democritus (e.g. IV.1, 764a7-12).

⁴ The last part of this definition, which specifies its function and end, is necessary to distinguish sperma from other types of useful residue of ultimate nutriment (e.g. fat: 727a33-7).

⁵ See also *GA* IV.1, 765b8-15, 766b8-15. Commentators are divided on whether or not Aristotle recognises female sperma. There are some passages where Aristotle seems to deny that females produce sperma (e.g. 727a26-30); however, in those cases “*sperma*” appears to mean male semen (i.e. *gonê*). Female sperma is explicitly mentioned in several passages (e.g. 728a26-7, b23, 750b4-5, 767b16-17, 771b20, b22-3). Indeed, as we have seen, Aristotle thinks it is because the female produces sperma that she is a “starting-point” of generation (716a11-13). Nevertheless, Aristotle stresses that what she produces is not the *same kind* of sperma as the male “as some allege” (727b6-7, 728a27-31).

⁶ Cf. *An* II.1, 413a2-7: “The body is that which exists potentially; but just as the eye-jelly and the capacity to see make the eye, so too the body and the soul make the organism. Thus it is clear that no soul exists in separation from the body. Likewise for certain parts of the soul (if it naturally has parts); for in some cases the actuality of these <parts of the soul> is the actuality of the parts <of the body>.”

⁷ The exception here is intellectual soul, since it is not the capacity of any organ (compare the qualification on “some cases” in *DA* 413a2-7). Intellect presents a special puzzle when it comes to transmitting soul (736b5-8).

⁸ One might point to a special pneuma inside the semen as the matter for the soul (cf. *GA* 736b30-737a7). I do not have space to discuss this alternative, except to say that this is not Aristotle’s position.

⁹ The change in question is the evaporation of the semen (cf. 737a15-6).

¹⁰ This is confirmed in *GA* II.5 when we learn that this part of the soul comes from the mother (see below).

¹¹ *GA* I.20, 729a9-12; I.21, 729b18-19; II.1, 732a4-5; II.4, 738b26-8. In other places Aristotle simply says the male contributes the “starting-point of the change” (*arkhê tês kinêseôs*), e.g. I.2, 716a4-7; I.21, 730a24-30; II.4, 740b25-6. Although this is not equivalent to his role as supplier of form, in certain contexts the two are bound up with each other.

¹² Aristotle even compares menstrual fluid to prime matter (*GA* I.20, 729a32-3). As we shall see, this is not exhaustive of the mother’s contribution to reproduction though.

¹³ “Zygote” is the closest English equivalent to Aristotle’s “*kuêma*”, which means “the thing generated from the initial interaction of male and female contributions” (724b18). “Embryo” is too broad for this, while “foetus” refers to the organism after its primary structures have been formed.

¹⁴ This is the traditional interpretation of *GA* II.5 (e.g. Peck 1990, xii). Allan Gotthelf has suggested to me that the father's contribution must include nutritive soul and that all *GA* II.5 commits Aristotle to is the idea that the mother *can* provide nutritive soul and *in some cases* (viz. wind-eggs) actually does so: but these cases should not be taken as a model for what normally happens.

¹⁵ At *GA* II.6, 744b16-27 the embryo's generative nature is compared to a household manager (*oikonomos*) that "constructs the flesh and the somatic parts of the other sense-organs out of the purest material, while it constructs bones and sinews and hair out of the residues".

¹⁶ This is what Aristotle seems to mean by saying the organ and function come into being *together* and not one before the other (*GA* IV.1, 766a5-7; cf. II.1, 734b22-4: "Sperma...has a movement and a principle of such a kind that once the movement ceases each part comes into being ensouled."). Nevertheless soul-capacities are explanatorily prior insofar as they explain why organs have the structure they do and thus why the nature of the embryo builds them in the way that it does (II.6, 743a36-b18).

¹⁷ This seems to be the force of Aristotle's statement at *GA* II.5, 741a13-14 that the father's contribution is "the capacity to make (*poiëtikon*) this sort of soul" rather than simply *being* that soul. On my reading, the way to "make" an Aristotelian soul is to construct the organs that discharge the corresponding capacity (since Aristotelian souls are capacities of organs). Thus, what the father directly supplies through his semen is the capacity to construct sensory parts (**see below**). Moreover, if we think of the generating capacities (*dunamis*) of the embryo's soul as capacities of the embryonic heart, then the way to cash this out is in terms of organising the region of the heart that governs the development of the sensory system. Likewise for the mother's contribution.

¹⁸ **By "a Coriscus or a Socrates" Aristotle means those properties that make the generator an individual, as opposed to a male or human being. For the significance of this see further below.**

¹⁹ **For the idea that a science must attempt to identify the "more precise" causes of a phenomenon see *Physics* II.3, 195b21-5.**

²⁰ We also find *kinêsis* being used in this way in the account of sense-perception in *GA* V.1-2. For the idea of a *kinêsis* bearing informational content see Aristotle *On Memory* (e.g. 452b23-4: "the *kinêsis* of the fact" and "the *kinêsis* of the time"). For alternative accounts of T1 see Morsink 1982, Balme 1987, Cooper 1988, and Furth 1988.

²¹ Aristotle does attempt to give an account of the general principles of **the theory (specifically, "displacement" and "relapse")** in terms of physico-chemical processes (768b16-35). However, that account remains incomplete and quite tentative. Indeed, Aristotle tells us that the job of giving a complete . All we are given are some basic remarks about how the project of translating these principles into the language of Aristotle's chemistry might be accomplished.

²² See *Metaphysics* K8. This inference seems to depend on an equivocation of the term "accidental", namely "incidental" versus "by chance". Eye colour may be accidental in the first sense even if not in the second, and K8 only applies to what is accidental in the second sense.

²³ Aristotle does not say exactly which individual differences he has in mind in T1; he only mentions properties that make the generator “a Coriscus or a Socrates” (as opposed to simply “a human being”). It does seem reasonable, however, that he has some kind of facial features in mind like eye colour and nose shape, since these are the sorts of features where family resemblances are most conspicuous (the very phenomenon Aristotle sets out to explain in *GA* 4.3). But the specific examples are irrelevant. The point is that some sub-specific differences – whatever features make the generator “a Socrates” – belong to the individual *katho gennêtikon*.

²⁴ For the relation between “formal nature” and “soul” see *PA* 1.1, 641a22-33. In *De anima* 2.4 Aristotle says that generative soul is essentially the capacity to reproduce the form and substantial being (*ousia*) of the individual in a different material body (415a26-8), while the nutritive soul is the capacity to maintain that form and substantial being in the same body (416b3-24). While both capacities essentially belong to the same part of the soul, the reproductive capacity is said to be teleologically primary (416b24-6).

²⁵ Lennox has convinced me that this would also be consistent with the view that inherited resemblances are due to the matter. For both *GA* V and *Meteorologica* IV show that we can have scientific knowledge of universal material-level causes.

²⁶ In *GA* I Aristotle tells us that “the parts” are matter for the animals: “the non-uniform parts are matter for the entire animal as a whole, the uniform parts for the non-uniform parts, and the so-called elements of bodies are matter for the uniform parts” (715a9-12; cf. *PA* II.1). However, these are material causes of *being* an animal; they are the matter out of which *the existing* animal is composed. Menstrual blood and the various “residues” of nutritive blood are material causes of *becoming* an animal; they are the matter out of which *the developing* animal is constructed. This reflects Aristotle’s distinction at *PA* I.1, 640a10-12 between studying animals as they actually exist and studying them in the context of generation.

²⁷ Compare *Physics* II.7, 198a25-7. There Aristotle says that the efficient cause refers to something *specifically* the same as these (*viz.* the father), not *numerically* the same.

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