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A dark business, full of shadows: Analogy and theology in William Harvey [☆]

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ABSTRACT

In a short work called *De conceptione* appended to the end of his *Exercitationes de generatione animalium* (1651), William Harvey developed a rather strange analogy. To explain how such marvelous productions as living beings were generated from the rather inauspicious ingredients of animal reproduction, Harvey argued that conception in the womb was like conception in the brain. It was mostly rejected at the time; it now seems a ludicrous theory based upon homonymy. However, this analogy offers insight into the structure and function of analogies in early modern natural philosophy. In this essay I hope to not only describe the complex nature of Harvey's analogy, but also offer a novel interpretation of his use of analogical reasoning, substantially revising the account offered by Guido Giglioni (1993). I discuss two points of conceptual change and negotiation in connection with Harvey's analogy, understanding it as both a confrontation between the border of the natural and the supernatural, as well as a moment in the history of psychology. My interpretation touches upon a number of important aspects, including why the analogy was rejected, how Harvey systematically deployed analogies according to his notions of natural philosophical method, how the analogy fits into contemporary discussions of analogies in science, and finally, how the analogy must be seen in the context of changing Renaissance notions of the science of the soul, ultimately confronting the problem of how to understand final causality in Aristotelian science. In connection with the last, I conclude the essay by turning to how Harvey embeds the analogy within a natural theological cosmology.

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In a short work called *De conceptione* appended to the end of his *Exercitationes de generatione animalium* (1651), William Harvey developed a rather strange analogy. To explain how such marvelous productions as living beings were generated from the rather inauspicious ingredients of animal reproduction, Harvey argued that *conception* in the womb was like *conception* in the brain. It was mostly rejected at the time; it now seems a ludicrous theory based upon, at best, homonymy.

Harvey's explanatory resources were not up to the task of accounting for the complex yet orderly phenomenon of generation, even by his own standards. But his response, the analogy of womb as brain, is a fascinating attempt at explaining generation, and offers insights into how analogical reasoning worked in early modern

natural philosophy. We might describe this analogy as psychological, but we must be careful in understanding what this means. In early modern Europe to speak of *psychologia* was to speak of the soul, all three faculties of the living body, rational, yes, but also the vegetative and sensitive souls. Indeed, I shall argue that Harvey's analogy must be seen in light of Renaissance debates about the science of soul and its proper method.¹ Understood in this context, Harvey's analogy allowed for a possible unification of the vegetative and rational souls, which operate alike in making their respective products. Both operations happen according to design, their products arranged by foresight and wisdom; *teleology* is of the utmost importance. But here the analogy comes to the limits of naturalistic explanation, for generation happens only as if it were

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¹ For some relevant discussions of changing conceptions of the soul, see [Wolfe & Van Esveld \(2013\)](#) and [Henry \(1989\)](#). For a more complete discussion, see [Vidal \(2006\)](#).

by foresight; the actual entities involved are not actually so competent. The apparent teleology of generation presented Harvey with an explanatory conundrum: how could generation happen in a rational way and yet not be rational? How could it be wisely designed but not wise?

In discussing the structure and aim of Harvey's analogy, I explore two points of conceptual change and negotiation important for our understanding of natural philosophy in this period. The first understands the analogy as a moment in the history of psychology, focusing on how explaining generation depended upon making sense of a process that was seemingly idea-driven. In Harvey's Renaissance intellectual context, this meant making sense of final causality, something bound up with his Renaissance conceptions of the soul. In fact, not just the meaning of *soul* but of *nature* itself is at stake, and here I expand upon the work of Guido Giglioni, whose (1993) "Conceptus uteri/Conceptus cerebri, note sull'analogia del conceptimento nella teoria della generazione di William Harvey" remains one of the few works dealing with this analogy. Giglioni notes Harvey's use of the concept of soul, but he dismisses an important element: the relation of soul to nature and God.²

Here then is the second point of conceptual change, where Harvey's analogy comes up against the boundary between the *natural* and the *supernatural*. My goal is to reconstruct Harvey's philosophical struggle to understand generation, understood in light of some of the history of attempts by natural philosophers to accommodate the seemingly *purposive* nature of living things. In Harvey's context, such purpose was often understood as divinely designed, and Harvey's account is embedded in a natural theological cosmology.³ Harvey attempted to explain generation through natural, and somehow also psychological, causes—but to explain how those causes could be psychological-yet-not, he turned to the supernatural design of natural things themselves.

I proceed as follows. I first provide some context for the analogy (Section 1), before moving on to introduce the analogy itself (Section 2). I then articulate my novel interpretation (Section 3). There I discuss why it was rejected, how Harvey systematically deployed analogies, how the analogy fits into contemporary discussions of analogies in science, and how the analogy must be seen in the context of late Renaissance humanism and the science of soul. In connection with the last, I discuss how we can complete our analysis by shifting from analogy to (natural) theology (Section 4).

1. Background

It is clear from *De generatione* that Harvey turns to analogical explanation because no other explanation based upon his observations was forthcoming: it was a last resort. It is less clear that this move was forced upon him by some of those very observations.

Two were most pressing: first, Harvey could find no matter from the male in the womb prior to conception; and second, he observed that development happens part by part, over time.⁴

The first major problem for Harvey's explanation of generation concerns the causal efficacy of the male's contribution: though Harvey knew the male provided semen, he never saw any trace of it in the womb after coition.⁵ All he knew was that, once transmitted to the female, the male's seed—somehow—caused the egg⁶ to become fruitful and begin the process of development, all *without* direct contact. Its action, he concluded, must be immaterial.⁷ He writes:

From the male proceeds only the procreative or plastic power [*vis procreativa, sive plastica*] that renders the egg fertile but constitutes no part of that egg. For the geniture⁸ which is emitted by the male...in no wise enters the womb⁹ (in which the egg is perfected), nor indeed...can it by any means penetrate into such places, much less reach the ovary near the middle of the body...¹⁰

So the male's semen imparts what Harvey calls a plastic power (*plastica vis*) that acts upon the female's womb and, from there, upon the unfertilized egg, but never upon the egg itself.

This lack of material presented a deep epistemological and ontological problem for every theory of generation available: all philosophers argued that there must be *some* material transmission of the fertilizing power of semen. In agreement with both Aristotelians and even most mechanical philosophers, Harvey refused to countenance action at a distance, and thus he was at a loss as to how the male's sperm fertilizes the egg. It must act immaterially, transmitted through the medium of the female's body, somehow rendering her whole uterus fertile and able to transmit its fertility to the egg.¹¹ Harvey writes: "...it will at the same time be apparent that everything that has been handed down to us from all antiquity concerning the generation of animals is erroneous, and that the foetus is made neither from the seed of the male nor of the female, nor from a mixture of both of them, nor is constituted out of menstrual blood...."¹² The analogy, as we shall see, helps explain this mysterious action of the sperm.

This is a confusing point, and it is important to avoid a common misunderstanding that Harvey turned to analogy because he had shown that there was no *material* cause of generation. Elizabeth Spiller asserts that, "...Harvey introduces a new analogy to explain how reproduction can occur with only an efficient but not a material cause."¹³ A similar mistake seems to underlie Eve Keller's analysis: "Harvey's determination that the semen has no material contact with the egg surely threatens the nature of paternity, since without physical continuity between father and fetus the role of the father in generating the fetus becomes ambiguous."¹⁴ Keller's

² Giglioni (1993, p. 11). I have been assisted with the Italian by Marina Baldissera Pacchetti. All other translations are my own (unless noted), though I have of course benefited from past translations.

³ For an excellent recent discussion of natural theology see Peterfreund (2012).

⁴ I note that one might frame Harvey's observations here in terms of Kuhnian anomalies, and, indeed, this might be a profitable mode of analysis. However, as my focus is here upon analogies, and not on the status of Kuhn's account of science, I set aside these issues.

⁵ See Harvey (1651, Ex. 6).

⁶ This is in the case of chickens, of course. The case of non-egg laying animals was more mysterious since the mammalian egg would not be discovered until von Baer. Harvey does introduce his own concept of an egg as a stage found in all animal generation, but I have not here space to fully describe it.

⁷ Of course, because he worked without a microscope, Harvey's observations here led him astray, as Leeuwenhoek and others would show towards the end of the seventeenth century.

⁸ Harvey uses the term geniture since, strictly speaking, semen is not a true seed, a term Harvey reserves for his new concept of the egg and for plants.

⁹ One must distinguish between the vulva and the womb, the latter of which is where the egg is located. Harvey's research convinced him that the male's semen could not pass from the vulva to the womb. See Harvey (1651, Exs. 5–6). I use 'womb' and 'uterus' interchangeably.

¹⁰ Harvey (1651, Ex. 26, p. 80). See also Harvey (1651, Ex. 27, p. 82ff) and Hirai (2007, p. 379).

¹¹ Here Harvey also uses another analogy, between the semen and contagion. This analogy is interesting in itself, as is the relation between it and the one under consideration in this paper, but I have not room here to discuss these issues.

¹² Harvey (1651, Ex. 40, p. 109).

¹³ Spiller (2004, p. 98)

¹⁴ Keller (2007, p. 105).

'surely' here is without any basis: Harvey's theory in no way threatens paternity, for his discovery did not in any way cast doubt that males were needed for fertilization, nor that the offspring resembled the father. Instead, his discovery only adjusted the causal theory of how that process was effected, which, as he says, is quite mysterious given that the matter of the emission never reaches the place of actual fertilization, though it does of course enter the female's body before it disappears.¹⁵ So there is at least this *distal* material cause. A further material cause of generation proper was never in doubt, and it remained basically the same cause as Aristotle had postulated in his theory of generation, namely, the matter provided by the female, which forms the body of the egg. It's hard to imagine how Harvey's natural philosophical theory, then, was a threat to traditional understandings of paternity.¹⁶

The second problem arising from his observations concerned how the embryo formed. Harvey argued that the fertilized egg was an intermediate sort of entity, at once an origin and an end: it is the end of the process of the interaction between male and female, yet it was also the origin of the fetus, whose own end was the completed offspring.¹⁷ Harvey conceived of the soul according to Aristotle's metaphysics: it is the *form* and *actuality* of the living body, and thus the soul of an offspring can only be present when the offspring is complete. In terms of soul, then, the fertilized egg is a combination of male and female forms, but it does not yet have the fully actualized soul of the offspring. The fertilized egg has a minimal soul—a vegetative soul—responsible just for growth and generation.¹⁸ So what happens during generation is a gradual process through which the body of the offspring comes to be organized with its requisite parts and configuration, a process by which the soul of the offspring comes into actuality.

This process of soul actualization was called by Harvey *epigenesis*, and although Harvey understands it in this metaphysical light, his argument for it was based upon observation. Key here was one of Harvey's experiments, in which he took a number of fertilized eggs from hens, incubated them, and observed them backlit by candlelight and opened on consecutive days. Thus Harvey constructed a detailed picture of the way in which development progresses, and determined that this process happens part-by-part, over time, in a specific and regular order.¹⁹ He observed that the egg, prior to development, contained no tiny preformed parts, but consisted of two homogenous parts, the yellow and the white.²⁰ The embryo therefore moves from being an unorganized, non-functioning body to an organized, functioning body with all the requisite parts: a body with a fully actualized soul. This process of coming into being is very complicated: it is a process by which a part comes into existence and grows, by which, for all intents and purposes, the matter of the embryo seems to organize *itself* into parts, moving from

homogenous to heterogeneous.²¹ What is more, this process happens in *due order*, which is to say, it is *regular* and *systematic*, first this part coming into being, then the next, always in the same order in the same sorts of creatures.

Harvey thus found himself having to explain an extremely complicated, systematic, and regular process, yet one whose component parts seemed hardly competent enough to effect such a monumental task.

2. Analogy

In *De conceptione* Harvey noted certain anatomical similarities between the impregnated womb and the brain, and he took seriously that the products of both are called *conceptions*.²² He drew on these similarities and argued that there were changes observed in the uterus when it is prepared for conception that make it even more brain-like: "...the uterus appears thicker and more fleshy, and (in so far as the inner surface is concerned, truly, the place of the future conception) it becomes more tender and is comparable in smoothness and softness to interior of the ventricles of the brain...."²³ On the basis of this (putative) observation,²⁴ Harvey argued that,

...seeing that the substance of the uterus that has been made ready for the conception is so very like the constitution of the brain, may we not justly suppose that the function of each of them is also alike...?²⁵

Harvey's argument was motivated by his observations, and depended upon the principle that similar structures imply similar functions and similar operations, something akin to an axiom of early modern anatomical inference.²⁶ Harvey adduces further evidence by a common strategy for elucidating analogies, a certain kind of feature matching between the source and target domains (see Fig. 1 below).²⁷

If, as Harvey thought, structure and function are linked, it follows that a similar structure implies a similar function:

...since Nature (whose every work is admirable and divine) has established such an organ, (namely the brain) by whose sensitive faculty and power the conceptions of the rational soul exist in it, that is, desires and arts and the principles and causes of so many and so varied works, of which man... is the author through imitation, why should we not think that this same Nature, which created the no less admirable structure of the womb and gave it a similar constitution to execute the office of conception also designed it to a like function, or at least an analogous one [*functioni consimili, vel saltem analogae*], and wished to use an organ that is in every way similar for a work that is

¹⁵ Because of this purported fact about the mode of transmission, Harvey deploys a number of other analogies such as contagion or magnetism to characterize how the sperm as material transmits the formal power contained within in that material.

¹⁶ Keller (2007, p. 106). I do not doubt that Harvey was a sexist by our standards, and that we can ferret out some of his ideas about the place of women from his scientific work—but it seems at best a gross exaggeration to argue that, his analogies in the *De conceptione* are aimed at foreclosing, "...the possibility of male control in generation and to entrench instead male preeminence by progressively reassociating the female with matter and the male with the pervasive power of spirit" (Spieller, 2004, p. 109). For a more sober assessment of some of these issues in Aristotle, see Henry (2007).

¹⁷ Harvey (1651, Ex. 26, p. 76).

¹⁸ And eventually, the embryo gains a sensitive soul, and, in humans, a rational soul.

¹⁹ See Harvey (1651, Exs. 42–45, pp. 113–125).

²⁰ Many of Harvey's observations here are mistaken because he did not use a microscope, e.g., his observation that the blood is the first part of the fetus to come into being.

²¹ Harvey (1651, Ex. 45, p. 122).

²² The word 'conceptus' is used for both.

²³ Harvey (1651, p. 294).

²⁴ In talking with contemporary medical researchers about the observations here, it is not clear what exactly Harvey was referring to, and whether the properties he asserts as in common between womb and brain are not the sort of properties often shared by various sorts of tissues. But we can safely set aside these concerns for this paper.

²⁵ Harvey (1651, p. 295). "...cumque adeo substantia uteri ad concipiendum parati, sit cerebri constitutioni persimilis: quidni merito suspicari liceat, utriusque etiam functionem esse similem...."

²⁶ This principle stems, in part, from Aristotle's teleological biology, but even more so from the somewhat Panglossian attitude of Galen in his *De usu partium*. See Hankinson (1989). This is not to say that every part was thought to have a function, but rather that one should start of *assuming* that a part has a function.

²⁷ On feature matching, see Bartha (2010, pp. 197–207).

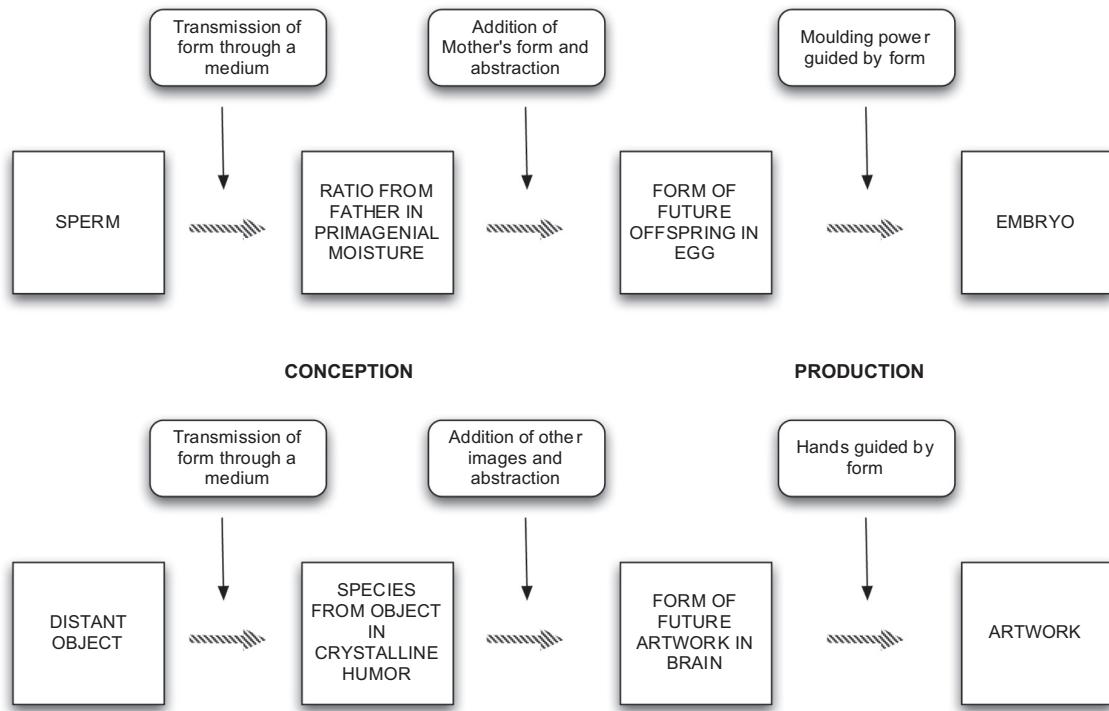


Fig. 1. A schematic overview of Harvey's analogy.

similar? For because a skillful craftsman accomplishes his works by the artful use of one instrument to one end, the same to the same and like to like, so that from the substance and form of the instruments a man may easily judge of their use and action, no less certainly than Aristotle has taught us to know their natures from the bodies of animals and the shape of their parts...²⁸

Harvey was not just inferring that brain and womb have similar functions (to wit, conception), but that the processes by which these conceptions are produced are also analogous. Brain and womb operate similarly if not identically, for a wise craftsman does not waste an instrument. Following in a long philosophical tradition, Harvey attempted to understand generation on the model of artistic production.

This analogy is an assimilation of the rational and vegetative souls, in so far as both faculties have the power to create complexity from simplicity. In fact, the 'lower' vegetative faculty is the more powerful due to its innate expression of Godly, rather than merely human, reason.²⁹ Given this assimilation, how does Harvey build the analogy? Remember that for Harvey, following Aristotle, the soul is essentially emmattered; even the rational soul is in some way related to human anatomy.³⁰ So Harvey conceives of both sorts of soul, rational and vegetative, in terms of their relation to complex physiological systems, systems that describe how very particularly arranged and constructed organic parts discharge the functions they are designed to perform. To construct the analogy, Harvey relates anatomical features he identifies as important in natural and artistic

generation with the functions and parts of soul and body they are related to, delineating each system in so far as he can, guided by similarities in form and function.

I start with one of these similarities, not noted in earlier discussions: the female's material contribution of the pre-fertilization egg acts like the eye transmitting sensation to the brain. This is a vital aspect of the analogy, and serves an important role in connecting the conception systems of the brain to those of the uterus. Harvey calls this material contribution the *primigenial moisture*,³¹ which he describes as akin to the prime matter of the Scholastics:

...the most homogenous, the purest and clearest body definable, in which all the parts of the chick are present *in potentia* but not *in actu*, Nature seeming to have granted it that which is common to the first material shared by all things, namely to be capable of all forms potentially, but to have none actually. So the crystalline humor of the eye is itself devoid of color in order that it may be capable of taking on all colors....³²

The primigenial moisture is the substance upon which the plastic power acts to form the parts of the embryo by epigenesis. This moisture has a power due to its material nature: just as the eye, when it views something, somehow takes on the colors of that thing, so too can the primigenial moisture take on the form transmitted by the male, which is understood as like an image received by the primigenial moisture. As noted above, the male's sperm must act immaterially, that is, analogously to vision and imagination, the first steps in conception in the case of artistic production.³³ So, just as the thing viewed transmits its image through the medium of air

²⁸ Harvey (1651, p. 296).

²⁹ See Harvey (1651, Ex. 50, pp. 145–146). I discuss this below.

³⁰ Harvey discusses the brain and its relation to the rational soul in Harvey (1616, p. 316).

³¹ See Harvey (1651, Ex. 72, p. 252), the title of which is 'De humido primigenio.' Harvey names it 'moisture' after, as he puts it, "the Arab's" terminology, which in Latin is 'ros', meaning dew.

³² Harvey (1651, Ex. 72, p. 252).

³³ I must note at the outset that Harvey's theory of vision is never presented by him, and it remains unclear exactly what he thought. It seems to have more in common with Medieval and early Renaissance theories than with accounts contemporaneous to him.

and light, and is then conceived of in the brain, so too is the male's sperm able to impart its 'image' to the female's egg through the medium of her reproductive tract.³⁴

Now we turn to epigenesis. Just as the artist constructs the work in stages according to the idea of the artwork in her mind, which in turn is based upon her perceptions of the thing to be represented, so too does generation happen according to the idea of the future offspring, based upon the 'perceptions' transmitted by the parents. In the *Praefatio* to *De generatione*, Harvey writes explicitly on conception in art:

... Art is the definition of the work [*ratio operis*] implanted in the artist's mind...that which we perceive in sensible things differs from the thing perceived and is that which is retained in the imagination or the memory. The former, the thing perceived, is the exemplar, the Idea, the informing form [*exemplar, Idea, forma informans*]; the latter is the imitation, the *Eidos*, the abstracted appearance [*imitamentum, Idos, species abstracta*].³⁵

Transposing this to the case of generation, the sperm transmits an 'idea,' an informing form, and this is the intentional object 'seen,' so to speak, by the uterus and transmitted to the primigenial moisture. When combined with the female's contribution, this produces the form of the future offspring in *potentia*,³⁶ the *eidos*. That is, it is the abstracted representation of the male and female such that an offspring of the same kind can be constructed. Key here is the term 'definition' (*ratio, logos*), which, as Aristotle articulated in the *Organon*, signifies what something is, its essence.³⁷ Logos is central to understanding soul, for, as Aristotle writes in the *De anima*, soul is the "... substance [of the body] according to its definition [*rationem*], and moreover this is the essence [*quod quid erat esse*] of such a kind of body..."³⁸ So what is transmitted by the male is an aspect of soul, form, a part of the account of the future offspring, a definition of its very essence.³⁹

We might call this a plan, in the sense of a blueprint, for this *ratio* contains the information needed to construct the fetus. Indeed, Harvey elsewhere calls the male's contribution a 'precept [*praecepto*]' that grants "...the definition, the form and laws [*rationem, formam, ac legem*] of the future fetus..."⁴⁰ So the male's contribution provides the plan of the future offspring and the set of rules according to which it is constructed by epigenesis. Harvey can thus use the brain/womb analogy and this 'precept' to explain the process of epigenesis: it is analogous to how an artist works with the conception of the future work in mind:

For just as we fashion from the conception of a form or an idea in the brain its likeness in the our works, so does the idea or appearance of the genitor remaining in the uterus generate a foetus like to himself by the help of the formative faculty, that

is to say, by imposing upon its work this immaterial appearance. It happens in the same way as art, which is the *eidos* or appearance of the future work, produces its like when it is acting and begets it in the matter [*est eidos sive species operis futuri, simile in agendo profert, & in materia gignit*]...So that what instruction effects in the brain...its analogue is bestowed on the uterus by coitus with the male [*quod disciplina in cerebro efficit...analogum ejus coitus maris in utero praestet*]...⁴¹

So in the same way that, in vision, just the form and not the matter of intentional species are transmitted from the external thing to the eye and then used by the brain to abstract concepts, the male sperm transmits his species through the female's reproductive tract without any material. The male's form is then abstracted in combination with the female's to create the form of the future offspring.⁴² How these forms become abstracted is unclear, as Harvey does not discuss it, but what is important to note is this process of abstraction accounts for another aspect of generation: namely that the offspring's form is not just that of the father or mother, but rather a combination of both. The egg, using its innate plastic power, builds the fetus, step-by-step, part-by-part, by following the *ratio* contained within it.

There is, however, a fundamental disanalogy between womb and brain: this whole process of generation happens without any actual foresight, thought, or design:

That is to say, the vegetative faculty of the parents [*facultas parentum vegetativa*] generates, and the seed finally arrives at the form of the foetus, in the same way in which the spider spins its web, birds build their nests, incubate their eggs and protect them, and bees and ants prepare their habitations and hide their food for future use. Clearly they do this naturally and by their innate disposition, and not with any foresight, education, or deliberation [*non autem providentia, disciplina, aut consilio*].⁴³

This is the major problem with any psychological or idea-like metaphor: in order to get any explanatory mileage out of a psychological concept in these situations, one must use those characteristics that are unique to the realm of the mental, that is, intentional and rational processes, but, at the same time, deny that in the non-psychological case that any such processes are really occurring or are occurring only in some suitably metaphorical way.⁴⁴

Harvey's attempt to do this understands the cause in an Aristotelian manner, arguing that the final cause (the form of the future offspring) must exist before the efficient cause (the plastic power) such that it can move the efficient cause according to the *telos* of development:

The efficient moves since it is impelled by the final cause [*causa finali impellitur*]. In every efficient there inheres, in a way, the

³⁴ It seems at least mildly paradoxical to think that immaterial causation cannot act at a distance because it must be in contact with the body it is acting on, despite being immaterial. Remember, though, that in the Aristotelian context, forms can travel, but, at each point, they must have a 'location', so to speak, even though they are not strictly enmattered at each point. So the form transmitted by the male has a series of locations (first in the womb, then in the oviduct and finally in the egg), even though at each point this form is not restricted to the matter of the womb, oviduct, or egg. Still the idea remains a difficult, perhaps paradoxical, one, and it is no wonder that Harvey is at a loss here to understand it.

³⁵ Harvey (1651), *Praefatio*, p. B3.

³⁶ It is in *potentia*, because the actualized soul cannot exist without the completed body, as discussed above.

³⁷ Aristotle (1552a), Lib. I Cap. 4, p. 257. Note that the location of this passage in this edition is different from the modern one, where the passage is located in chap. 5. See also Aristotle (1552b), Lib. IV, Cap. 12, p. 222.

³⁸ Aristotle (1552d), Lib. II, Cap. 1, Vol. 11, p. 52. Note that '*quod quid erat esse*' is the translation of '*to ti en einai*', a very difficult phrase and concept in Greek, and which gave the Latin translators much trouble, hence their neologism of '*essentia*'.

³⁹ More properly, part of its essence, as it must be combined with the female's contribution. Furthermore, this cannot be the full essence, the soul of the future chick *in actu*, but only in *potentia*, for, as argued above, epigenesis just is the process whereby this essence comes into actuality.

⁴⁰ Harvey (1651, Ex. 29, p. 89). We can assume that the female, too, grants such a precept. The male must further provide the 'spark' that starts the process of generation.

⁴¹ Harvey (1651, p. 295).

⁴² Harvey does not call this process in the egg 'abstraction'; in fact, he never talks about how the forms of the parents are integrated. Abstraction seems as good a term as any, especially given Harvey's larger analogy, but as Tawrin Baker has pointed out to me, the focus for Harvey is the process of actual production, in both the case of the womb and the artistic analogue, not what we might term the more cognitive process of image and concept formation.

⁴³ Harvey (1651, Ex. 50, p. 146).

⁴⁴ The exceptions are panpsychist theories. See Zammito (2006) and Wolfe (2010).

account of the end [*ratio finis*]; by this final cause, the efficient is moved, operating with foresight [*providentia*].⁴⁵

Note, that, because of how the final cause directs the efficient cause, the efficient operates as if (but not actually) by foresight. The construction of the fetus is analogous to artistic production: just as the artist paints or sculpts her object according to the account of the artwork existing in her, so too does the uterus construct an egg by a set plan (epigenesis), according to the ratio of the future offspring that is contained, somehow, in the egg. Thus Harvey deploys two stages in the process of mental conception as analogues of two stages in the process of generation, a fact not noted in earlier analyses of this analogy: the process of seeing something by means of one's visual faculties and how that image is abstracted and stored in imagination and memory as a concept or idea becomes the model for how fertilization is effected, and the process by which that concept is used by the artist to guide their productions becomes the model for how epigenesis occurs.

Finally, I here lay out Harvey's analogy schematically, modeled on Hesse's (1966) conception of *tabular representation* of an analogy. This gives a good overview of the matched features that Harvey takes as providing the rationale for the analogy Fig. 1:

A few things to note about the figure I have divided the analogy into the two stages, conception and production. Each of the square boxes represents an entity or an entity in a state of affairs, such as the sperm, a distantly viewed thing, or the *ratio* from the sperm inside the primigenial moisture. Each of the rounded boxes labeling the arrows represents a causal process involving those entities.

Before moving on to a more substantive interpretation, it will be helpful to discuss some of the analogy's weaknesses. Hesse stressed the importance of the relations between each part of the analogy, that is, between each step in the figure above.⁴⁶ She distinguishes between the *negative*, *positive*, and *neutral* analogies within a model. The negative analogies are those parts that are ascribed to one side of the analogy but not the other, the positive analogies those aspects shared by both sides, and the neutral analogies those aspects not yet known to be either positive or negative to be used for making predictions about further correspondences between the sides of the analogy.⁴⁷ The positive analogies should be clear enough from the forgoing discussion of the correspondences between source and target domains, and from Fig. 1. As for neutral analogies, Harvey is here not interested in *prediction* but rather in *explanation*.⁴⁸ But it will be useful to briefly consider some negative analogies.

Regarding the correspondence between objects in the analogy, though Harvey argues that it is brain and womb that are analogous, the causal picture he develops does not have the womb corresponding to the brain, but rather the egg. For the egg is truly the site of fertilization and conception, not the womb. Indeed, Harvey

repeatedly stresses that the soul of the egg is responsible for the production of the fetus, and not the womb, though he does wonder at the beginning of *De conceptione* what the male's fertilizing power affects, the uterus or perhaps the female as a whole.⁴⁹ Because Harvey is convinced that the egg is entirely responsible for the creation of the embryo, his analogy between the womb and brain falls apart, since even Harvey believes there are no structural similarities between egg and brain to support an inference to similar functions.

There is a further empirical problem here, one that concerns the similar 'smoothness and softness' that Harvey claims to have observed between the place of conception in the womb and the ventricles of the brain. It is unclear exactly what Harvey is referring to, though his contemporaries do report similar findings about the 'softness' of the womb during conception (though, interestingly, most stress rather its change in thickness as being the most important change).⁵⁰ Further, even if womb and brain played analogous roles in Harvey's depiction of production, he would be doing no more than replacing one mystery with another: no one, Harvey included, had any idea how the brain worked, and how the structure of the brain was designed to complete its function of conceiving and thinking.⁵¹ So, while it was obvious how the structure and composition of the skull contributes to its function of protecting the brain by being hard, by surrounding the brain, and so on, it was entirely mysterious how the 'smoothness and softness' of the womb and ventricles in any way contributed to conception.

Another negative analogy concerns Harvey's comparison between the primigenial moisture of the egg and crystalline humor of the eye. Harvey is behind the times in locating the seat of vision in the crystalline humor: Kepler in his *Astronomiae pars optica* (1604) had shown on the basis of geometric reasoning that the crystalline humor is not where the image is projected, and that the image is actually sent to the retina.⁵² More importantly, the way in which the primigenial moisture receives form is different than how the crystalline humor was thought to do so according to Harvey. Whereas the crystalline humor receives and then transmits the form of the thing seen *without* taking on its shape or colors (at least permanently), on the contrary, it is the very purpose of the primigenial moisture to materially instantiate the received form. So, while instead of immediately taking up the shape of the parents,⁵³ it does so rather by epigenesis, there is still a negative analogy here. Indeed, it is the uterus, rather than the primigenial moisture, which seems to be the true analog, for, like the crystalline humor, the uterus somehow transmits the form to the egg without taking on its properties.

With these few negative analogies, it is clear that Harvey's comparison had some serious difficulties. These negative analogies give us part of the reason as to why Harvey's analogy failed, not because

⁴⁵ Harvey (1651, p. 299).

⁴⁶ She calls these 'horizontal relations', because of how she lays them out in a tabular form. My diagram obviously does not fit this characterization as it is rotated 90 degrees from the orientation of Hesse's table.

⁴⁷ Hesse (1966, pp. 8–9).

⁴⁸ Which are quite separate things, as van Fraassen (1980) argued.

⁴⁹ See Ex. 27, which is titled: "The egg is not the production of the womb but of the soul".

⁵⁰ See, for instance, Crooke (1615), Bk. IIII, Ch. 13, p. 239, or those works upon which Crooke's is based, Bauhin (1605) and Laurentius' (1600).

⁵¹ For various suggestions of what the ventricles might do, see Harvey (1616, p. 314). Here he recounts that they are somehow for intelligence, that they are for the easy movement of the brain in its systole and diastole, to prevent it from collapsing upon itself, and so on. Inspired by Harvey, later in the century Thomas Willis produces one of the first detailed anatomical and philosophical discussions of the brain, his (1664) *De cerebri anatome*.

⁵² Kepler (1604, Cap. 5, p. 158ff). See also: Crombie (1991, pp. 89–115), who points to Vopiscus Fortunatus Plemptius's *Ophthalmographia* (1632, 1648), (1648) as well as William Briggs's *Ophthalmographia* (1676, 1686); also the influence of the popular *Recreation mathematique* (1624) by Jean Leurechon, and its English translation *Mathematical Researches* (1633); Felix Platter's *De corporis humani structura usu* (1583) is also relevant. Kepler also mentions the physician and anatomist Johannes Jessenius' (1601) *Anatomia Pragensis*, who studied at Padua in the late 1580s. The reception of these works amongst the physicians is hard to trace, and what influence is detectable on these optical and anatomical matters seems mediated by Scheiner, mostly in the second half of the century. So whether Harvey should have known of these things, or how current knowledge of these matters amongst the anatomists was, is rather unclear. However, it is reasonably clear that his knowledge or rather lack of it did affect the reception of the work. My deepest thanks to Tawrin Baker for discussion on this subject.

⁵³ I note that Harvey thinks that some insects are generated in this way, receiving their form all at once like a stamp into wax; he calls this sort of imperfect generation metamorphosis. See Harvey (1651, Ex. 45, p. 112ff).

the analogy was absurd, but because of defects in its logic and in its empirical support.

3. Interpretation

Harvey was explicit that his speculative explanation of generation was a result of his complete befuddlement:

It is a dark business, full of shadows, and yet I will dare to put forward a suggestion by means of a problem, so that anyone may see that I don't only eliminate other's opinions, but also, in some way, to be seen to convey my own opinions to the community. And yet I do not wish the things I have to say about this business to be taken as though I believed them to be pronouncements of the Oracle, or as if I desired to extort every man's vote in my favor. I only ask as my just deserts the liberty I freely grant to others, to put forward as true those things which in this whole dark business seem probable until such time only as their falsity may be openly proved before all men.⁵⁴

Harvey could not satisfactorily resolve the mystery of generation. But, unlike in the case of the final cause of circulation as discussed in the eighth chapter of the *De motu cordis*,⁵⁵ Harvey did not refuse to speculate.

I turn now to offer a substantive new interpretation of Harvey's use of analogy, broken into four parts. First, the failure of Harvey's analogy is best explained not (only) as being a logical/empirical failure, but also by the changing metaphysical fashions of the seventeenth century. Second, Harvey's use of analogy in *De conceptione* is not something unique in his oeuvre, and by looking at how he used analogies elsewhere, we can distinguish two distinct ways they are deployed. These two ways depend on the two separate but interdependent phases of natural philosophical method that Harvey distinguishes, following Aristotle: the *historical* and the *scientific*. Third, Harvey's use of analogy fits nicely into recent philosophical accounts of analogical reasoning, and offers some insights into the use of analogy as a means of establishing plausibility. Fourth, Harvey's analogy must be understood in the context of Renaissance humanism, in particular, in terms of the debates about the nature of the soul and the proper method for its investigation. Given this context, I argue that Harvey's brain/uterus analogy should be thought of in terms of presenting a unified science of soul, one that tries to address one of the deepest problems of Aristotelian science: the nature of final causality.

3.1. Metaphysical fashions

Giglioli argued that Harvey deeply disappointed those, then as now, who desired a 'well defined response' to the issue of reproduction. Harvey conflated the psychological and organic orders of reality in a way that could not help but lead him and others astray.⁵⁶ Yet this interpretation of Harvey's invocation of teleology, foresight, design, and other seemingly psychological properties in order to explain the process of development belies the fact that the problem of generation was something simply beyond the meager explanatory resources available to the early modern philosopher:

they often had no choice but to use the psychological to understand the organic, despite Descartes' and later philosopher's protestations that such domains were metaphysically distinct. Justin Smith has rightly argued that, while Harvey was out of philosophical fashion, his troubles were anything but unique:

Accounts of fetal development as an end- or idea-driven process were doomed to fall into disfavor in the seventeenth century. However, it would prove much harder to eradicate immaterial, guiding principles of development from embryological explanation than many modern thinkers would have liked. This is because, as the example of Harvey makes very clear, such principles would continue to appear indispensable in the explanation of organic phenomena long after physics, the study of inorganic bodies, had proved, for many, perfectly able to do without them.⁵⁷

The complaint that Harvey's response was not well defined would thus apply to most responses to the problem of generation. There is thus an important point here about the limits of early modern epistemology and metaphysics to account for organic phenomena, and thus Giglioli's argument that Harvey's analogy conflated the psychological and the organic does little to help us understand this moment in the history of natural philosophy.

N. R. Campbell once argued that a good analogy is often essential for finding a valuable theory, one to which scientists should devote their resources, which Paul Bartha describes as a way of establishing plausibility.⁵⁸ So for an analogy to be accepted, it must itself be founded upon uncontroversial and well-accepted assumptions, it must be amenable to the dominant modes of metaphysical and philosophical analysis. Thus the failure of Harvey's analogy to find any support or elaboration is unsurprising, due not (just) to intrinsic features of Harvey's idea, but to changing philosophical assumptions and post-Cartesian hostility to understanding the physical and organic as substantially related to the mental.

3.2. Historical and scientific analogies

Giglioli further opines that this resort to an argument by analogy by the great Harvey would be "...no small surprise to a reader of the *De motu cordis*..."⁵⁹ But it is rather Giglioli's remarks that are surprising, and any purported shift in Harvey's epistemology is a mirage: both works employ analogical reasoning. Consider the dedication to King Charles in *De motu cordis*:

The heart of living things is the foundation of their life, the Prince of all their parts, the sun of their Microcosm, that upon which all growth depends and whence all vigor and strength emanates. Equally, the King is the foundation of his kingdom, the sun of his microcosm, the heart of his state, from whom all power flows and all grace emanates.⁶⁰

Harvey begins his great work with an analogy between the macrocosmos of the universe and the microcosmos of the human body, with a complementary analogy between body, universe, and political organization, emphasizing the central source of power and motion in those respective realms, heart, sun, and king. This rather complex analogy was one that had deep roots in the culture of Renaissance Europe.

⁵⁴ Harvey (1651, p. 293).

⁵⁵ Harvey (1628, Cap. VIII, p. 42).

⁵⁶ Giglioli (1993, p. 13).

⁵⁷ Smith (2011, p. 167). Related to these issues are debates about monsters, which, according to the 'accidentalist' thesis of the 1700s, was understood in a deliberately anti-teleological, and anti-'mind-like' way. See Wolfe (2005).

⁵⁸ Campbell (1957, pp. 129, 142). See also Bartha (2010, pp. 16–17). I discuss this further below.

⁵⁹ Giglioli (1993, p. 8).

⁶⁰ Harvey (1628, p. A2).

Walter Pagel, the preeminent twentieth century scholar of Harvey, argued that Harvey's philosophy must be understood as being based upon, and motivated by, an Aristotelian cosmology of circles, analogically linking man to heaven.⁶¹ Pagel's contention was that Harvey was, as it were, 'primed' to discover the circulation because of his adherence to this philosophy of circles, seeing circles everywhere: thus Harvey was prompted to think of the circular motion of the blood by the analogy between body and cosmos, between weather and generation, and so on, as well as by the analogy between the lesser circulation (from the heart to the lungs and back to the heart) and the flow of blood in the body more widely. The point I hope to make is only that Harvey made rather explicit use of analogies in *De motu*. There is one place I want to note, one that Pagel commented upon:

Harvey remains in the sphere of analogy for most of the rest of this memorable eighth chapter [of *De motu cordis*]: the analogy of the circular motion of the blood with that of air and rain and in turn with the circular motion of the celestial bodies emulated by them, also with cyclical generation...and with cycles of storms and aerial phenomena which are due to the circular motion of the sun...Still within the realm of the microcosmic analogy, the heart emerges as the true sovereign of the body—restoring as it does fluidity, heat, power and the balm of life to the blood that reaches it from the periphery, cooled, coagulated and effete...⁶²

Interestingly, the eighth chapter was the only place where Harvey dealt with the final cause of the circulation. As I argued above, final causality caused the second major problem Harvey attempted to overcome with his analogy, and both works and both analogies are concerned with natural teleology.

There are different ways in which Harvey uses analogy between *De motu* and *De generatione*, as well as different ways within each work. For instance, in *De motu cordis*, the micro/macrocosm analogy provides an inspiration for a claim about how to describe the structures and motions of animal bodies: the blood moves in a circuit around the body like how the bodies in the heavens move around in their orbits. In *De generatione*, however, the analogy between brain and uterus provides rather a way of final causally explaining the biological process of reproduction. One might be tempted to interpret this difference in the use of analogy by means of the philosopher's hoary distinction between the context of discovery and that of justification. And it does seem that Harvey's analogies in the eighth chapter of *De motu cordis* are like Kekulé's dream of the snake,⁶³ suggesting a solution to the various *problematum* and controversies surrounding the motions of heart, blood, and pulse by means of a circuit of blood.

But the analogical reasoning of the *De generatione* does not fit so neatly in either of these contexts. There is, however, a relevant Renaissance distinction that helps us understand the differences in the deployment of these analogies: the distinction between *historia* and *scientia*, a fundamental bifurcation in Harvey's method. The former should be understood as the collection and arrangement of facts by means of multiple divisions, the latter as the deduction of causal explanations from those histories. As James Lennox has insightfully argued, the first twenty-five exercises of Harvey's *De generatione* are organized according to the strictures

of Aristotelian *historia*, even down to justifying his inductive inferences on the fact that nature does nothing in vain.⁶⁴ In exercise twenty-six, Harvey moves on to *scientia*, that is, to inferences about causes from those observations, the first of which was his new concept of the egg, an important locus of causal activity in generation.

So some of the analogies inspiring and involved in Harvey's description of the circulation fall into the category of *historia*, since they are related to the organization of observational facts relating to the structures and movements of the parts. The analogy between the weather cycle and the movement of the blood has to do with the gross structure they have in common, namely, the way in which both can be understood as moving a fluid in something approximating a circle, over the course of which there are changes in the analogous fluids' natures. Indeed, one might point out that there is a gap involved in each: the gap between water turning into clouds and then coming back as rain water, and the gap in the circuit from the left to the right chamber of the heart. In each case, though the exact method was not clear, Harvey knew that it was the same substance leaving and coming back: the water was somehow transferred to the cloud from the ground (Harvey did not know of evaporation and condensation), and the blood was somehow transferred from the arteries to the veins (Harvey did not know of the capillaries). So what is at stake in this sort of an analogy has to do with the structural similarities between the analogues. This accords well, too, with how Harvey uses analogies in his lecture notes for the Lumleian Lectures, the *Prelectiones anatomie universalis*.⁶⁵ In these notes, Harvey most often uses analogies in order to describe the structure and composition of various parts, the stock and trade of these sorts of lectures, especially in those contexts where the part in question could not be clearly seen in dissection due to rotting, or the difficulty of extracting or viewing it *in totum* or intact, or accounting for its inevitable variations, and so on. So, for instance, Harvey compares the gall bladder's shape to that of 'a rather long pear',⁶⁶ and he compares the appearance and structure of the inflated lungs as analogous to an ox's hoof.⁶⁷

The brain/uterus analogy from *De generatione*, meanwhile, falls into the category of *scientia*, having to do with the explanation and the causes, especially the final causes, of the structures and movements described in the earlier parts of the treatise. The analogy isn't about the correspondence in structure between brain and uterus, for, indeed, as I demonstrated above, these physical correspondences were (part of) Harvey's evidence for the analogy. Instead, it has to do with the correspondence in function between the two parts, and the ways in which the causal processes operating in mental conception can be used to understand the processes of uterine conception. Aspects of Harvey's analogy between the king and heart, state and body, in the *De motu*, then, fall into this category, insofar as they have to do with interpreting the functionality of the one part (the heart) in its system (the veins, arteries, lungs, and blood) in terms of the others (king and country, sun and solar system). This political kind of analogical interpretation of the body's functionality was something quite traditional among anatomists, going back to Aristotle's analogy of the heart as the 'seat' of the soul, noting that Aristotle's terminology had political overtones.⁶⁸ Harvey offers a variety of similar, but slightly different,

⁶¹ I have doubts about Pagel's thesis regarding circles, but I will not here argue for this. Circularity is discussed in many of Pagel's works including (1967, pp. 4, 20, 31, 37, 40, 97, 111, 153) and (1976, pp. 54, 82, 89, 90–93, 98, 103–119, 121–124, 220, 242, 327). The idea is taken up in extended by Thomas Fuchs in his (2001) *The Mechanization of the Heart*, Trans. Marjorie Grene. I cannot resist pointing out, however, that Grene, too, "...cannot really agree with him in his Pagelian reading of Harvey on circles" (p. xiv).

⁶² Pagel (1976, p. 54).

⁶³ Kekulé purportedly dreamed of a snake biting its own tail, and this dream supposedly spurred his discovery of the cyclic nature of the structure of benzene. Circles apparently have a long history of (analogically) inspiring discovery!

⁶⁴ Lennox (2006). For a more general discussion of *historia* and its uses, see Pomata (2005).

⁶⁵ This was a series of lectures Harvey gave from 1616–1627, given to aspiring surgeons and doctors on the whole art of surgery.

⁶⁶ Harvey (1616, p. 148).

⁶⁷ Harvey (1616, p. 276).

⁶⁸ Aristotle's terminology involves the root terms *archon* and *kurion*, both of which originally had a political connotation involving rule and control.

analogies for interpreting the overall functionality of various parts at the end of his unpublished treatise on the movements and mechanical structure of animals, the treatise Gweneth Whitteridge called *De motu locali animalium*. There he asks, for instance, “... is the heart the musician or the architect? The brain, the choir-master, surveyor. The nerves, clerks. The little nerves, controllers, prompters, directors. The muscles, singers, workmen, etc.”⁶⁹ It is clear that these were speculative analogies, given that he presented these numerous interpretive analogies interrogatively, never asserting to which, if any, he might subscribe.

We thus have two modes of analogical reasoning in Harvey, one historical that helped Harvey *describe* the structure of the parts of animals, the other scientific and which helped him *explain* the functionality of those parts. And so, even in what Giglioni implies is his most empirically sound work, Harvey self-consciously used speculative analogies in the hopes of understanding the functionality of the circulation and heart and blood system.

From our historical vantage we can see that Harvey was ill equipped both experimentally (working without a microscope) and theoretically (having no knowledge of a chemistry that had yet to be invented) to answer any question as to the purposes of the circulation. And, again from our vantage, we can see that the situation is the same in the case of generation, perhaps worse, as the relevant discoveries that would grant scientists insight into reproduction were centuries away. So *De motu* and *De generatione* are not different because the one does not use analogy and the other does. Giglioni implies that the latter represented some sort of shift away from an earlier empiricism, but we see rather the affirmation of Harvey's empiricism in how he carefully distinguishes between those cases where he is speculating and those in which he is on firmer observational ground, between cases of tentative analogical explanation and more certain analogical description.⁷⁰

3.3. Analogy, possibility, and plausibility

So how should we interpret Harvey's analogy, if, *pace* Giglioni, it should not be understood either as an ill-defined response nor as an uncharacteristic slip into the unscientific and non-empirical, but as a normal strategy for Harvey?

Throughout his paper, Giglioni repeats that the reason Harvey failed to make any progress in explaining explanation was due to his improper importation of the psychological to understand the organic: “The *concipere* of the mind and the *generare* of the uterus remained hopelessly tied to two different orders of reality, impervious to any transfer of meaning.”⁷¹ This is not a helpful way to think about Harvey's analogy. There are two mistakes here. The first, which I discuss in this section, is that Giglioni seems to misunderstand the purpose of an analogy, which *just is* to put together very different sorts of things, their ‘order of reality’ notwithstanding. Scientific analogies can be used to make something plausible—a cause, an effect, etc.—by showing how it is like something else, and thus not *sui generis* but rather a common pattern, a regularity found throughout nature.⁷² Second, discussed in the following section, Giglioni

misunderstands the meaning of psychology in Harvey's context, and thus the larger significance of the analogy.

Analogy is central to Aristotle's logical and biological works—indeed, comparison was a central aspect of method in Ancient philosophy, as important to Socrates as to Galen. Discussing Aristotle's use of analogical reasoning, Roger White notes that,

Aristotle starts out with a basically very simple idea, the idea that there are two different ways to compare things—a direct comparison where one notes common properties of the two things, and an indirect comparison where, whether or not two objects have significant common properties, one effects the comparison by introducing a third and fourth term. He then shows in practice how that basic idea can be adapted in a wide variety of contexts in support of his claim that it is the indirect comparisons that can yield genuinely new insight; the direct comparisons are usually trivially obvious and the results obtained from such comparisons correspondingly trivial.⁷³

So for Aristotle, analogy was a way of indirectly comparing things that yielded important insights. In biology, for instance, there are two sorts of ways things can be said to be similar: they can be very close indeed, varying only by ‘the more and the less,’ or they can be alike by analogy.⁷⁴ The former is about intra-kind variation (the differences between one sort of bird and another), the latter about inter-kind variation (the differences between a bird and a dog). The latter is of importance, because, as Aristotle cogently argues, despite being related by analogy, there are a great deal of universal truths that can be determined by interkind⁷⁵ comparisons—for instance, though birds and dogs are not the exactly the same kind of animal, their hearts are the same kind of thing, differing insofar as is necessitated by their individual ways of life and environments. Harvey's method, inspired by Aristotle's, used this sort of analogical reasoning in his *De motu cordis* to great effect, employing facts from anatomies on many sorts of animals to determine the function of the heart, the arteries, the valves, and so on, across all animals that have hearts. Concerning the valves, for instance, Harvey uses information about the distribution of valves across animal kinds to undermine Fabricius' argument that the valves were made to prevent blood pooling in the crural (and other) veins due to the upright stature of man.⁷⁶ Contrary to Giglioni's remarks, analogies cannot be ruled out because they compare items of even drastically different kinds.

If we want to move beyond Giglioni's analysis, we must determine what insight it was that Harvey thought the analogy provided, and why it was plausible. Again, White's analysis of analogical reasoning is helpful: “*Analogy enables us to group together, as falling under a single concept, completely heterogeneous entities.*”⁷⁷ Giglioni's dismissal of the analogy's very possibility is distorting because it fundamentally misunderstands what is important about analogies: their ability to let us see *different* things as *similar*. Stronger in fact: we can see analogy as providing an entirely new category, an essential component of conceptual innovation in science. Especially in those situations where the phenomena are obscure and hard to understand, using an analogy to create a new

⁶⁹ This treatise was written in was written some time in 1627. Peter Distelzweig in unpublished work has argued that Whitteridge's title is a misreading of a section heading of only one part of that treatise. I quote here Whitteridge's translation, Harvey (1627 [1959], p. 151). There are numerous possibilities for interpretation here, and Harvey describes several, including hearts as generals, brains as kings, and so on: pp. 147–153.

⁷⁰ For a similar analysis, see Wolfe & Salter (2009).

⁷¹ Giglioni (1993, p. 22).

⁷² For a similar account of a use of analogical reasoning in Descartes, see Manning (2012).

⁷³ White (2010, p. 51). There is now a substantial body of literature concerning Aristotle's biology and its relation to his logical works. The best starting place is Lennox (2011).

⁷⁴ Aristotle (1552c), Lib. I, Cap. 4. See Lennox (2001, pp. 168–169). See also: Lennox (1990) and Pellegrin (1982).

⁷⁵ Figuring out what, exactly, ‘kind’ refers to in each instance Aristotle makes such a distinction is difficult. Aristotle sometimes names nine ‘extensive kinds’ (*megista gene*), divided into two groups based on being blooded or bloodless. For some discussion in the context of *De partibus animalium*, see Lennox (2001, pp. 156–157).

⁷⁶ Harvey (1628), Cap. 13, p. 55.

⁷⁷ White (2010, pp. 59–60). Emphasis original.

category is often an essential task for the scientist to get to grips with those phenomena, to begin to create the language and ways of thinking needed to understand it. Thus Paul Bartha has noted that analogies are often used to found new paradigms,⁷⁸ and while this is not the case with Harvey's example, had it been successful, there might be some sense in which it would have founded a new paradigm of organic explanation, or, perhaps more likely, extended the existing Aristotelian paradigm. And so while Giglioni acknowledges that metaphors and analogies often seem necessary, he seems to dismiss their importance, writing that the task of later science is to deconstruct these 'very fragile bridges' based on metaphor, and rebuild them with the *concreta* of real science.⁷⁹

This might be true so far as it goes, but analogy is more than a 'fragile bridge', and, in fact, what we see in Harvey is an example of an extremely important use to which analogies are put, namely, expanding conceptual possibilities.⁸⁰ In Harvey's case, the justification for this expansion is provided by a kind of causal similarity or *vera causa* principle. The *vera causa* principle states that in order to be worthy of investigation, a cause has to be "...analogous to causes that are already known to have produced similar effects in other cases."⁸¹ In the case of the brain and the rational soul we have the same sorts of causal features that plague an account of generation: a kind of immaterial cause that informs the production of something material, a very profound case of final causation. In both artistic production and natural production, an idea—something immaterial (or, better, something *potentially* material)—is used as the guiding basis for structuring the complex but orderly way in which what that idea represents is materially instantiated (becomes actually material). For an early modern like Harvey, then, a reasonably similar way to understand the production of something as complex as a living thing was the model of human artistic production.⁸² Harvey's creative response to this problem was to offer an analogy to unify the rational soul and vegetative soul under the category of *conception*, made plausible by the resemblance between the causal processes and products in both domains.⁸³

What does this say about analogical reasoning in science? Analogy for Harvey acted as a guide and limit to envisioning the possibility and plausibility of scientific hypotheses about generation. Analogical thinking more generally allows scientists to express inchoate ideas in ways that make sense and seem plausible, creating new modes and fields of research. Evelyn Fox-Keller has expressed this idea beautifully:

...scientific research is typically directed at the elucidation of entities and processes about which no clear understanding exists, and to proceed, scientists must find ways of talking about what they do not know—about that which they as yet have only glimpses, guesses, speculations. To make sense of their day-to-day efforts, they need to invent words, expressions, forms of speech that can indicate or point to phenomena for which they have no literal descriptors....Making sense of what is not yet known is thus necessarily an ongoing and provisional activity, a groping in the dark...⁸⁴

Harvey's analogy should be seen not as anything illicit, but rather as a standard and necessary mode of coining and changing scientific concepts, central to his natural philosophical method. (Indeed, some linguists have argued that this kind of conceptual development and expansion by means of metaphorical thinking is central not just to scientific language but to all language use.⁸⁵) Harvey admits that his analogy here was speculative, that he deployed it as a last resort to sort out the dark business of generation. Harvey used the analogy to establish the plausibility of understanding the activity of both the rational and vegetative soul as similar enough to unite them under the heading of conception, uniting the operation of final causality in natural things by tying together these two very different orders of reality, as Giglioni names them. Harvey thus illustrates exactly that sort of scientific groping in the dark that Fox-Keller describes, something central both to scientific success and failure. This does not mean, of course, that such an analogy could not mislead,⁸⁶ or that the process of science often consists in the replacement of metaphorical bridges with more concrete ones, as Giglioni rightly notes.⁸⁷

Understanding the role of analogy in constructing plausibility arguments and establishing new concepts means that to suggest that, *in principle*, no analogy between the psychological and the organic could ever be fruitful is plainly false. Explaining the failure of Harvey's analogy in terms of Giglioni's illicit conflation is a non-starter, and that instead I shall now argue that we must see it as a creative, if flawed, attempt at unifying disparate elements of Renaissance natural philosophy concerned with soul.

3.4. Analogy and final causality

If an analogy is about establishing the possibility and plausibility that one domain is like another in terms of some pattern or regularity found in both, what pattern was Harvey concerned with? Harvey was not just showing that the uterus was like the brain, but that the causal processes found in conception (mental and uterine) could be grouped together as instances of a pattern found in different areas of nature (though limited to living things), instances of a regular and orderly process that reliably creates complexity from simple ingredients. In this section I discuss how, by means of this analogical conceptual unification, Harvey makes room for an expanded conception of final causality and of the science of the soul. First, I place Harvey in the appropriate (and, so far, neglected) context of late Renaissance natural philosophy. Second, I discuss Harvey's conception of the rational and vegetative souls, showing that what binds them together is that both are capable of achieving products that are complex through a process which is specific and orderly. The underlying aim here is to come to grips with one of the most problematic and difficult to interpret doctrines of Aristotelian science, final causality. In the next and final section of this essay, I tie this together by demonstrating how that second point of negotiation noted in the introduction, the line between the natural and the supernatural, functions in Harvey's theory of generation.

⁷⁸ Bartha (2010, p. 308).

⁷⁹ This comes out most clearly in the final paragraph of Giglioni (1993).

⁸⁰ See Bartha (2010, p. 199).

⁸¹ Snyder (2006, p. 201) and Bartha (2010, p. 17).

⁸² Indeed, the craft analogy is important in a variety of scientific contexts, starting in Ancient Greece but relevant to natural philosophy through the Enlightenment. On the analogy in Aristotle, see Broadie (1990, pp. 389–404). For Harvey's relation to artisans, see Salter (2013), though I must note that I do not agree with the argument or conclusions of this paper.

⁸³ This is a common way of using analogies in early modern science, according to a recent quantitative attempt at categorizing the use of analogies in this period; see Gingras & Guay (2011).

⁸⁴ Fox-Keller (2002, p. 117).

⁸⁵ Lakoff & Johnson (1980).

⁸⁶ See especially: Nancy (1996, p. 133). Lakoff & Johnson (1980) make a similar point, p. 147.

⁸⁷ Giglioni (1993, p. 22).

Harvey understood his subject matter as an investigation into the teleological union of soul and body.⁸⁸ It was an investigation into ‘what is common to body and soul,’ as Aristotle describes his approach in *De sensu*. R. A. H. King notes,

The phrase ‘common to body and soul’ refers to a central group of problems in ancient philosophical psychology, including not merely interaction between soul and body, but parallelism and teleological or functional relations. Furthermore, it marks the point where philosophy and more empirically minded approaches meet, including both those of Aristotle in *Parva Naturalia* and of medical writers.⁸⁹

In fact, the term *psychologia* was itself created during the Renaissance to designate the set of problems stemming from the *De anima* and the works of the *Parva Naturalia*, which, by Harvey’s time, had come to be seen as necessitating empirical investigation, at least among a certain group of physicians and philosophers.⁹⁰ Over the course of the Renaissance, there was a shift whereby the natural philosophical aspects of investigation into soul became separated from the more overtly theological and metaphysical aspects, emphasizing anatomical investigation over metaphysical disputation. This change was spurred in part by the new Humanist translations of and commentaries on the works of Aristotle and Galen (especially those of Alexander of Aphrodisias),⁹¹ as well as the religious edicts of the Pope.⁹² It is here that one begins to see the revival of anatomy as core to investigation into the soul, and as central to medical theory. Interestingly, as its importance and prestige increased, anatomy was also used by theologians and metaphysicians to understand the soul!⁹³ Returning to its Aristotelian roots, the science of the soul began to insist that the soul must be understood as essentially *enmattered*, as being united with its organic body, and thus necessitating anatomical study.

Harvey fits nicely into this tradition, something noted, if not exactly in these terms, by Andrew Cunningham and Cynthia Klestinec in their work on Fabricius, Harvey’s teacher at Padua. Both argue that Fabricius saw his work as an investigation into the faculties of soul, organized along the lines of Aristotle’s animal works in combination with Galenic concepts of physiology and the investigation thereof.⁹⁴ However, there was a single soul faculty that escaped the purview of the natural philosophers: the rational soul. And it is exactly this soul that Harvey invokes in his explanation of generation as being analogous to the vegetative soul. Harvey’s analogical unification here should thus be seen in light of the larger changes in conceptions of the soul and its proper investigation, such that, in amalgamating the functioning and powers of the rational and vegetative souls, we can see Harvey as attempting to expand the possibilities of naturalistic (and especially anatomical) study of the soul.

The first point of conceptual change I noted in the introduction, the meaning of psychology, thus comes to the fore, since Harvey’s proposal opens the way for understanding (some of) the powers of the rational soul as being importantly similar to those of the vegetative, such that both parts of the soul could be studied through anatomy and observation.⁹⁵ The boundaries of what could be con-

sidered properly the subject of psychological or idea-driven natural processes was still under negotiation, and Harvey’s analogy serves as an argument for a wide reading of what psychology was about and what ideas could explain. In many ways this is just to point out the centrality of final causality to any Aristotelian science.

This goes hand in hand with the second point of conceptual change, insofar as understanding nature in this psychological way often forced philosophers to embed their ideas in a larger natural theological cosmology. Thus Harvey argues not just that rational and vegetative processes happen along similar lines, but also that the vegetative ones are superior. We can understand this as an essential step in dethroning the rational part of the soul as mysterious and to be studied only through non-empirical means.

...that the vegetative faculty, or that part of the soul that makes and conserves a man, is by far more excellent and more divine and more nearly resembles God than the rational part of the soul, whose excellence nevertheless we extol with wondrous praises above all the faculties of all animals, as though it held law and authority over the others, and as though all created things were subservient to it. Or then we must confess that, in the works of Nature, there is neither foresight, nor skill, nor understanding, but they seem such only to our concepts, which judge the divine productions of Nature by our own arts and faculties [*in naturae operibus, nec prudentiam, nec artificium, neque intellectum inesse: sed ita solum videri conceptui nostro, qui secundum artes nostras & facultates*]...as if the active principles of Nature produced their effects in the same way in which we are accustomed to in creating by means of art, that is by judgment, and the discipline acquired by the exercise of the understanding or the mind [*intellectu sive mente*].⁹⁶

For Harvey, what binds the rational and the vegetative parts of the soul is that they are both capable of creating things, from simple ingredients, which bear all the marks of intentional foresight and wise design. But, in fact, the vegetative soul is closer to the rationality of God than to the rationality of human beings, since its products are far beyond the means of mortal minds to even imitate. This upturns the traditional classification of the powers of soul: “For in generation, the male uses neither council nor understanding; nor does a man generate with any part of his rational soul, but by means of his vegetative faculty, which is not counted among the primary and more divine faculties of the human soul, but the very least.”⁹⁷ Importantly, though foresight marks both aspects of soul as similar, in the case of the vegetative soul it is only the analogue of foresight that is present, for Harvey does not think that sperm and egg make decisions in the same way a human being does, by intentionally reasoning through the steps. I shall return to this important disanalogy in the final section, but for now I want to identify this problem as a (perhaps *the*) problem of *final causality*. In the case of the rational soul, the foresight evidenced in artistic productions is a result of the process of conception and then intentional following of that concept as a guide for the creation of whatever is being made. But in the case of the vegetative soul, the way in which this final cause guides

⁸⁸ This comes out in the first parts of Harvey (1616). The best starting place for some of the relevant history is Park (1998). See also: Michael (2000), especially p. 148n.2 and references therein.

⁸⁹ King (2006, p. 3).

⁹⁰ For a nice overview of how Aristotelianism changed in the Renaissance, see Kessler (1990).

⁹¹ For which, see Mitrovic (2009).

⁹² The relevant edict is the Pope’s *Apostolici Regiminis* after the Lateran Council in 1513, which forced philosophers to argue against Averroist conceptions of the soul, and for the soul’s immortality.

⁹³ For example, Philip Melanchthon’s made a good deal of use out of anatomical findings in his commentary on *De anima*. See Mengal (2000).

⁹⁴ Cunningham (1985). See also: Klestinec (2004, 2007, 2011)

⁹⁵ For an overview of some aspects of this history, see Vidal (2006).

⁹⁶ Harvey (1651, Ex. 50, pp. 145–146).

⁹⁷ Harvey (1651, Ex. 50, p. 145).

the efficient cause is different insofar as it is entirely an unintentional and unconscious following.

This problem is at the center of Giglioni's analysis of Harvey's analogy. But Giglioni gets a number of things wrong. He argues that Harvey's analogy was doomed to failure, taking inspiration from the response of Harvey's contemporary Marcus Marci:

...Marci elaborated in his *Idearum operatricium idea* (1635)...an embriogenetic model that was based on the assumption of a common root between seminal ideas and imaginative species. The *idea formatrix* is not only an *exemplar rerum*, but it also possesses a 'poetic' valence extraneous to the *species internae*: nevertheless, the productivity of the imagination, however reduced, legitimizes the assumption of common nature and possible semantic exchanges. But, as happened to Harvey, the approximation of the two scopes triggers an inevitable ontological failure. «*Quod si enim vim tribuamus speciebus internis*, asks Marci, *quid prohibet quo minus in cerebro quandoque generetur planta, aut animal?*» The answer of the doctor from Prague—that the action of the *species* does not go beyond the representation and their representation stops at the surface of things, without dealing with action—strongly excludes any analogic commingling, though it does not give an account of the effects of the maternal imagination on the fetus, which was accepted as a matter of fact. Now, if the brain cannot generate anything but the *species*, how can the uterus *concipere sine materia*, as Harvey sustained? And on the other side of the analogy, which Merci rejects with equal decisiveness, calling it only a metaphor, that '*nihili facit ad rem*': the uterus is an *agens naturale* and, unlike the action of a conscious thing, does not know the *ratio finis*.⁹⁸

Giglioni's analysis here is confused. Marci's reading of Harvey does not accord with what Harvey wrote, for he never maintained that brain cannot generate anything but the *species*, and, in any event, it's irrelevant because Harvey argued that what is transmitted in generation represents the entire idea of the animal, the emphasis being upon the mode of transmission, rather than the process of fetus construction. The issue of whether or not the *species* transmitted in vision represent the entirety of that thing or just its surface is just (another) failure of the analogy to hold perfectly in every part, but this does not necessarily invalidate it. And of course, Harvey does account for the fetus' construction in terms of the plastic power granted by the union of male and female, and which is analogous to the way in which the hands of the artist are guided by the idea contained in their brain. Giglioni's contention about 'productivity' thus seems misplaced. The *sine materia* line is also confused in that Harvey tries to account for what is transmitted as being potentially material in a way similar to how species are transmitted through a medium and into the eyes—what is being transmitted is, to put it in modern terminology, some representational content.

Giglioni suggests that the creativity of artistic imagination is what is at stake in the analogy, that what is important in the analogy is that the plastic power of the egg strikes a balance between natural law and the arbitrariness of the creative forces.⁹⁹ But this is simply to misunderstand the meaning of imagination for Harvey—imagination does not refer to any sort of creativity in the sense of creating something new, but rather only to the process by which images received from *species* are combined to form memories and concepts in the brain. Though Harvey never spells it out in detail,

what creativity there is in generation is involved with the fact that the offspring is somehow new, different from the parents. But this 'creativity' if it is such, is easily explained by Harvey's analogy, for in just the same way the concept formed by an artist in viewing some distant object is not identical to the original, and the product of such concepts (a painting, for instance) resembles the original but is not identical, so too in the womb does the resulting offspring resemble but is not identical to the parents. In fact, what is really at stake in Harvey's analogy is alluded to but not picked up by Giglioni. He comes closest when he writes that the analogy breaks down because the uterus does not 'know' the final cause.

Thus it is not an opposition between natural causation and creativity that is fundamental, but rather a mismatch between natural causation and the *orderly specificity* and *functional complexity* of generation. The sorts of efficient and material causes Harvey could rely on, heat, movement, and so on, were far from being able to account for the product of generation: such causes could not create something that happened in a regular manner (first this part, then this, in all kinds of animals observed) nor something that was made up of many individual complicated parts and yet was functionally integrated towards the well being of the animal. The mistake of the materialist philosophers, according to Harvey, was that they ignored these features of generation by attempting to explain them with resources not up to the task. For Harvey, if something looks designed, if something looks purposeful, that is, if it smells like a final cause, it must actually be a final cause.¹⁰⁰ And so his analogy is an attempt to understand the operation of these causes as expressions of the fundamental nature of organic beings, of their souls.

By attempting to unify the operations of the rational and vegetative souls, Harvey was gesturing at a way to extend Aristotelian science. This makes sense of Harvey's remarks *vis a vis* the vegetative versus the rational soul, but, *pace* Giglioni, this is not animistic tomfoolery, but rather an attempt to formulate a unified science of souls, following in the tradition he inherits from Renaissance and Ancient philosophers. If the possibility is now closed that there could be a transfer of meaning between these orders of reality, it was a live option for Harvey, one that might have helped unravel the mystery of final causality. No doubt Giglioni is right to point to this as one of the deeply problematic aspects of Harvey's analogy, but it is a metaphor that is found throughout early modern philosophy, and it may be one still with us in the form of information.¹⁰¹

4. Theology

Harvey's analogy was meant to extend the reach of his complicated and eclectic natural philosophy. At the center of this analogy, at the center of the unification of vegetative and rational souls, however, lies a fundamental disanalogy: the final cause operates only *like* the rational soul. Harvey's analogy thus opened him up to a host of problems about how this sort of cause operates outside of minds. Here I argue that, to, as it were, have his cake and eat it too, Harvey's analogy depends upon the border between the natural and the supernatural, and thus he turned from analogy to (natural) theology.

On the one hand Harvey denied that natural things (like wombs or spiders) operate by means of reason (like artists do), yet on the other hand, his analogy turned upon exactly those sorts of

⁹⁸ Giglioni (1993, pp. 20–21).

⁹⁹ Giglioni (1993, pp. 14–16).

¹⁰⁰ For which see footnote 33 above; Harvey (1651, Ex. 11, pp. 28–29).

¹⁰¹ I do not mean to throw doubt in any way on this concept, nor upon those explanations that use it, only to point out a similar at least underlying analogy. There is, however, a large body of literature in philosophy of biology about the status and interpretation of genetic information, teleosemantics, etc. Development systems theorists in particular have objected to informational concepts in biology as distorting; see: Griffiths & Gray (1994), Griffiths (2001) and Jablonka (2002). See also Griesemer (2005).

processes that *do proceed by reason*. So he is forced to offer some explanation as to how it is that these unthinking things can perform actions so complex that not even a human being with the full power of their reason could perform them. This significant negative analogy is thus part of the reason Harvey spends some time in *De generatione* describing how generation occurs within the larger metaphysical and cosmological order of God and Nature. In so doing, Harvey beautifully illustrates a larger pattern in early modern natural philosophy that Jacques Roger long ago noted: the fact that God becomes a central explanans of life and generation over the course of seventeenth and eighteenth centuries.¹⁰² A key problem was to account for epigenesis,¹⁰³ and if Harvey is any guide, it is no wonder that, instead of trying to explain it, many philosophers after Harvey simply denied it, and used God to explain and justify the existence of infinite invisibly small preformed parts, explaining generation by growth, by preformation or emboîtement as it would become known.¹⁰⁴

To defend his analogy, Harvey turns to another one: God as the Divine Craftsman. He explains how generation could occur as it does by means of a theological conception of the divinely crafted natures of those things involved in generation (an option not available to later philosophers who rejected the Aristotelian conception of natures). The foresight and art displayed by sperm and egg are to be understood, not in the way some neo-Platonists and other philosophers understood them, as actually employing reason, but as a secondary effect of God's miraculous design.¹⁰⁵ Thus the first efficient cause of generation could only be God and His wise design of nature. Harvey argued that the male and female are but *instrumental causes* of generation, the *primary cause* being God:

...in the construction of the chick the first efficient is required to use skill and foresight, wisdom, goodness and understanding far beyond the capacity of our rational souls [*& providentia, sapientia item, bonitate, & intellectu, rationalis animae nostrae captum longe superantibus*]. For it is that account of the future work, which acts for some determined end and arranges and perfects all things; and which forms the parts of the chick, even the smallest, for the sake of some use and some action [*alicujus usus & actionis gratia*], and looks out for not only the structure of the work but also to its welfare, ornament and defense. Now the male or his seed, either in coitus or after it, is not so qualified that to him can be attributed art, understanding and foresight [*ars, intellectus, ac providentia*].¹⁰⁶

There is no foresight in the process of epigenesis itself: the egg does not reason or plan its way to the fetus. Rather, God acts through a series of instruments which are each natured by Him to progress, grow and act so as to accomplish the construction of the offspring, all in certain specific, regular ways. Harvey neither thinks that natural objects act with actual foresight and wisdom, as human beings do, nor does he argue that God controls the process of generation directly, guiding the process as the sculptor guides her chisel. Rather, God is the ultimate cause of the natures of created things, not an active controlling force in the construction

of particular animals. So we have the analogy of God the Craftsman, with natural objects as His instruments. Don Bates writes that,

What accounts for regular and orderly changes in the world, then, are not randomly energetic atoms or educated agents but the law-abiding instruments of God. In fact 'all natural bodies are both the products and the instruments of the highest divinity.' Harvey has kept the Aristotelian model of craftsman, and instruments or forms, except that when it comes to processes [...] because of their wondrous complexity, must be continuously managed by the wisdom and foresight of God, who artfully makes his creations also serve as instrument.¹⁰⁷

Bates is surely correct that, for Harvey, the Aristotelian metaphor of nature as a craftsman has transformed into a sort of natural theological conception of God as the Divine Craftsman. However, Harvey's natural theology seems to embrace a view of God not where He continually manages Creation, but where all natural things follow His Law. God the Craftsman gave each natural thing its nature and this nature directs that object according His Design.

Harvey explicitly equates God with Nature,¹⁰⁸ and he writes that,

...Nature...and the vegetative soul...do both move and act by no acquired faculty (as we do) which may be distinguished by the name of art or prudence, but just as if by a certain order or mandate working according to laws...That is to say, the vegetative faculty of the parents generates, and the seed finally arrives at the form of the foetus, in the same way in which the spider spins its web, birds build their nests, incubate their eggs and protect them, and bees and ants prepare their habitations.... Clearly they do this naturally and by their innate disposition, and not with any foresight, education, or deliberation [*non autem providentia, disciplina, aut consilio*].¹⁰⁹

God's instruments are not themselves capable of foresight, they merely display what appears to be wisdom as a result of God having designed them to act in such regular ways. Their natures are just such that they act in this way, and thus only God can truly understand how these processes occur.¹¹⁰ Accounting for this regularity, or, perhaps better, embedding this regularity into his larger cosmological framework, is as close as Harvey comes to offering a full explanation.¹¹¹ Harvey had to turn to supernatural causation to understand natural causation, at least in those processes that were regularly specified and also functionally complex.¹¹²

In the end, then, Harvey knew his solution was unlikely to win approval, yet he offered it all the same, supplying what answers he could that fit his observations. I've shown Harvey struggling against a problem whose empirical and conceptual contours could only be explained through a speculative analogy embedded in a cosmos understood to be designed by God. This analogy of last resort, though it ultimately failed, should be of deep interest to philosophers and historians of science in that it provides insight into

¹⁰² Roger (1963).

¹⁰³ Harvey's other problem, concerning fertilization, was negated with the advent of microscopes and the discovery of spermatozoa.

¹⁰⁴ Pyle (1987).

¹⁰⁵ Harvey has in mind the doctrines of the physician Jean Fernel.

¹⁰⁶ Harvey (1651, Ex. 50, p. 144).

¹⁰⁷ Bates (2000, p. 591).

¹⁰⁸ See for instance, Harvey (1651), Ex. 41 and especially Ex. 50.

¹⁰⁹ Harvey (1651, Ex. 50, p. 146).

¹¹⁰ Perhaps analogies are as close as we mortals can come to understanding generation.

¹¹¹ This sort of explanation, especially in the form of preformationism, became a common refrain in embryological studies through the eighteenth century. See, for instance, Needham (1959 [1934], pp. 94, 236) and Pinto-Correia (1998, p. 20ff, pp. 149, 265).

¹¹² So one might compare Harvey's traditional response to this problem of understanding causality in relation to nature and to God with more radical responses that would become important after Descartes, such as Louis de La Forge's or Malebranche's occasionalism.

two points of negotiation in the history of natural philosophy, tracing the boundary between the idea-driven and the idea-less, and the border between the natural and the supernatural. Harvey's epistemological and metaphysical difficulties on these matters would not be the last: generation remained a stubborn problem for hundreds of years, the list of philosophers attempting to tame it including figures as diverse as Leibniz and Darwin. A dark business indeed.

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