

Chapter 10

Experience, Analogy and Mechanism in Maupertuis's Theory of Generation



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Abstract At the mid-eighteenth century, the formulation of alternative theories undermined the hegemony of preexistence in the debate on animal generation. The new theories were characterized by a revival of epigenesis, and by a naturalization of the explanatory models. A key text in the mid-century renaissance of epigenesis is Pierre-Louis Moreau de Maupertuis's *Vénus physique* (1745). While interpreters have unanimously acknowledged the role of this text in changing the course of the debate, the reasons for Maupertuis's originality have not been studied in depth. Also, the relationship between the *Vénus physique* and the mechanistic view of generation is not entirely clear. With respect to the first point, I argue that Maupertuis is original in the theoretical framework he develops. He adopts a strongly empiricist stance and is skeptical about the possibility of the human intellect attaining a reliable knowledge of nature. As for the second point, I show not only that the reference to mechanism, and to Descartes's work, is important in defining the terms of the controversy over preexistence. The appropriation of the mechanistic view, its updating, and eventual dismissal, are also important passages in the constitution of Enlightenment embryology, fostering the rise of a materialist approach in the 1750s.

10.1 Introduction

In the eighteenth century, the formulation of alternative theories progressively undermined the hegemony of 'preformation', namely the theory according to which a fetus is at least partly – but possibly completely, according to the version of preformation called 'preexistence' – formed before fecundation, in the debate on

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animal generation.¹ The challenge to preformation and preexistence came first and foremost from a revival of epigenesis, meaning the idea of a progressive development of the embryo, accompanied by an updating of the mechanistic view of viviparous generation and a naturalization of the explanatory models. In France, as recent studies have shown (Ferraro 2016), epigenesis was already reintroduced in the first half of the century in the context of the Cartesian tradition. At mid-century, however, a more radical turning point was to be produced in the controversy on generation, which associated epigenesis with a materialist stance (Wolfe 2014). A key text in the mid-century renaissance of epigenesis is the *Vénus physique*, published anonymously in 1745, in fact authored by the natural philosopher and academician Pierre-Louis Moreau de Maupertuis.²

While interpreters have unanimously acknowledged the role of this text in changing the course of the debate (Roe 1981, 2003), the reasons why the *Vénus physique* had such a groundbreaking role in the eighteenth-century controversy on generation still lie in obscurity.³ The critique of preformation and preexistence and the revival of epigenesis are obviously central motives (Hoffheimer 1982). Yet Maupertuis is especially original in the theoretical framework he develops. He adopts a strongly empiricist stance and is skeptical regarding the possibility of the human intellect to attain a reliable knowledge of the natural world.

The relationship between the argument of the *Vénus physique* and the mechanistic view of generation is not entirely clear either. Maupertuis proposes a mechanical model of viviparous reproduction updated with the introduction of a relational force, namely gravitational attraction, as the organizing principle of organic structures. This model is presented as a correction of the Cartesian mechanical account of epigenesis, with the introduction of a Newtonian treatment of force (Ibrahim 2003). Although overlooked in the scholarship, the critical relationship with the mechanistic view, particularly with Descartes, is in fact an important aspect of the reconfiguration of the debate on generation fostered by the *Vénus physique*. The reference to mechanism is important not only in defining the terms of the controversy with the theorists of preexistence. The appropriation of the mechanistic view, its updating, and eventual dismissal are also important passages in the constitution of Enlightenment embryology. In this sense, the *Vénus physique* might be described as a key turning point in the gradual passage from the predominance of mechanism to the emergence of materialism, and belongs in the ‘middle ground’ that exists between the two (Hankins 1985, 120; see also Gaukroger 2010, part 4).

I will start by considering Maupertuis’s critique of mainstream theories of generation, insisting on its theoretical stakes. I will underscore the empiricist and skeptical approach that Maupertuis adopts. I will then move on to detailing Maupertuis’s

¹On the conceptual distinction between preformation and preexistence, see Bowler (1971). In this chapter, the spotlight will be on preexistence, as Maupertuis concentrates his critique on this notion.

²For an analysis of the contents of the *Vénus physique*, with special attention to the social context and erotic style, see Terrall (1996, 2002), 211–226.

³Stéphane Schmitt, for instance, has compared Louis Bourguet’s epigenetic theory with Maupertuis’s, but only stresses that the latter’s solution is ‘much more radical’ (Schmitt 2014, 488).

own theory of generation, calling attention to the question of mechanism and the Cartesian heritage. I will finally discuss the further developments of the controversy on generation in the eighteenth century, in particular the rise of a materialist approach.

10.2 The Critique of Ovism and Spermatism

Maupertuis's critical appraisal of leading generation theories is organized into distinct sections, as embryological models are treated separately from metaphysical beliefs. I will start by analyzing Maupertuis's critique of the former.

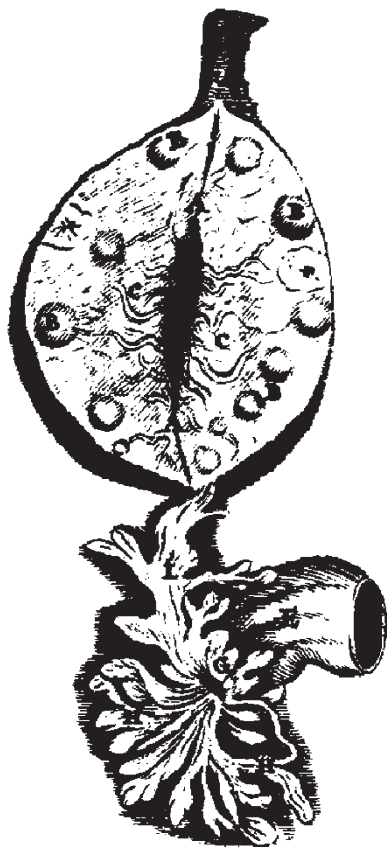
As of the seventeenth century, several naturalists had argued that the female egg was the sole principle of generation. The theory of 'ovism' was shaped on the analogy between oviparous and viviparous animals, relying on the discovery of ovarian follicles – analogous to eggs in mammals – which had been observed with a microscope in the 1670s. Among the advocates of ovism, the names of famous anatomists and microscopists such as Marcello Malpighi, Francesco Redi and Reinier de Graaf are to be reckoned (Pinto-Correia 1997, 16–64). Opposite to ovism was the coeval theory of 'spermatism', which made the masculine principle the sole agent of reproduction. Spermatism had been formulated after the discovery of spermatozoa and had among its proponents the leading Dutch naturalists Antoni van Leeuwenhoek and Nicolaas Hartsoeker (Pinto-Correia 1997, 65–104).

In the *Vénus physique*, Maupertuis first introduces and then criticizes ovism and spermatism, providing both empirical and theoretical arguments.

10.2.1 The Empirical Argument

On the empirical side, Maupertuis contends that ovism and spermatism are based on dubious scientific observations. Many naturalists had claimed to provide the ultimate proof of either ovism or spermatism, but still 'many natural philosophers consider them chimerical' (Maupertuis 1768b, 34). Maupertuis discusses the example of de Graaf's experiments on rabbits, and of his critic the Flemish anatomist Philip Verheyen. De Graaf had dissected female rabbits at several moments after coitus, arguing that, after 24 h, some change had occurred in the ovary, and that, at later times, he had found eggs first in the tubes, then in the uterus. He also claimed that the number of eggs observed in the ovary was the exact same as the number of those found in the tubes and in the uterus (Fig. 10.1). Verheyen, however, repeated de Graaf's experiments with a different outcome. While noticing the alterations and marks left by the eggs in the ovaries, he found no correspondence between the number of those marks (and hence the eggs) and the number of fetuses in the uterus. According to Maupertuis, the contrast between the experiments of two trustworthy

Fig. 10.1 De Graaf, Regnier. 1672. *De mulierum organis generationi inservientibus*. Leiden: Ex Officina Hackiana, page 193. Bayerische Staatsbibliothek, Munich. Public Domain Mark

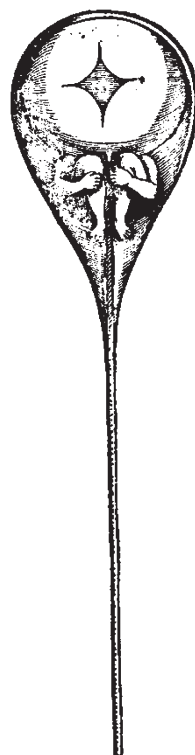


anatomists, such as de Graaf and Verheyen, proves that evidence in favor of ovism is (at best) questionable.⁴

The case with spermatism is more complex. It is not a question for Maupertuis of denying spermatozoa a role in the process of generation. However, this function is not ‘to be the animal itself’ (Maupertuis 1768b, 94), as the spermatozoon-man depicted by Hartsoeker in his 1694 *Essay de dioptrique* (Fig. 10.2) would suggest. In this respect, Maupertuis discusses at length the experiments on generation carried out by the English physician William Harvey (Harvey 1651). Harvey’s observations, which Maupertuis regards as highly reliable, contradicted the spermatist idea that semen is found in the uterus at any time between coitus and the first

⁴De Graaf’s observations on rabbits are in fact relevant in the history of anatomy, as they contain the first description of ovarian follicles. At a late stage of folliculogenesis, before ovulation, ovarian follicles are called ‘Graafian follicles’. On De Graaf’s experimental practice of anatomy, see Ragland (2008).

Fig. 10.2 Hartsoeker, Nicolas. 1694. *Essay de dioptrique*. Paris: Jean Anisson, page 230. ETH-Bibliothek Zürich, Rar 1383. Public Domain Mark



development of the fetus.⁵ This would prove that the experimental foundation of spermatism is far from strong.

In sum, Maupertuis's empirical argument against ovism and spermatism consists in presenting contrasting evidence in favor of and against these theories, in order to prove the uncertainty of both. The scientific validity of ovism and spermatism, which their partisans claimed to be well-established, rested in fact on precarious grounds.

10.2.2 *The Theoretical Argument*

Ovism and spermatism are inadmissible not only for empirical reasons, but also for major theoretical problems. In several works, Maupertuis expounds his theoretical views, characterized by a skeptical approach towards the limits of the senses and the intellect, and the boundaries of the knowable. According to Maupertuis, the human

⁵On Harvey's experimental practice, and theoretical approach, see Salter (2012) and Distelzweig (2016).

mind is fallible, and has limited powers. Accordingly, his approach towards scientific knowledge is conventionalist *avant la lettre* (Tonelli 1987). As Maupertuis stresses in the *Réflexions philosophiques sur l'origine des langues et la signification des mots* (1740),

What we call 'our sciences' depend so much on how we designate the perceptions, that I believe that the questions and propositions would be totally different if we had established other expressions for the first perceptions (Maupertuis 1768a, 268; see also Beeson 1987).

Maupertuis also defends a general principle according to which certainty is limited to the 'primary laws of nature' which 'the Supreme Being established in the formation of the universe', namely those 'that we constantly see at work in all phenomena' (Maupertuis 1768a, xii). The most famous instance of such a general law, which is most certain and carries the sign of the Creator, is the principle of least action, described by Maupertuis as a 'universal law of nature' (Maupertuis 1768b, 289).⁶

The application of such criteria to the analysis of ovism and spermatism leads Maupertuis to formulate the following objections.

- (a) The knowledge of sexual reproduction is uncertain because of the complexity and specificity of the processes involved. It is in fact possible that even the most expert observer had missed an important aspect of the phenomena at stake: 'In things that are so difficult to observe, could it not be the case that some circumstances eluded even the best observer?' (Maupertuis 1768b, 50). This argument follows both from the limitedness of human knowledge (perceptual knowledge, here), as well as from the equation 'generality equals certainty', 'specificity equals uncertainty'.
- (b) The microscope (and the telescope) endow men with a sort of 'enhanced sensibility'. However useful they might seem to scientific progress, these devices are, for Maupertuis, unfit to our limited intellects. The mental faculties of humans, as limited as they are, cannot deal with the information deriving from an enhanced sensibility, which they can easily misinterpret: 'Microscopes and telescopes have, so to say, provided us with senses so much beyond our reach, that they would belong to a higher intellect, but constantly point to the limits of ours' (Maupertuis 1768b, 46). In line with his empiricism, Maupertuis's solution consists in privileging sense perception, and ordinary experience: 'Our mind seems to be destined to reason only on the facts that our senses discover' (Maupertuis 1768b, 45–46).
- (c) All-encompassing systems such as ovism and spermatism – Maupertuis refers also to Harvey's system of generation, a *sui generis* ovism – want to shed full

⁶Maupertuis formulates the principle of least action while discussing the laws of optics. As he argues, there is a metaphysical principle grounding the laws of reflection and refraction, namely the principle according to which the 'quantity of action' – meaning the sum of the distances covered by a body in motion, each multiplied by the velocity with which the body travels through it – is minimized. On the principle of least action and its philosophical characterization, see Van den Abbeel (2017) and Storni (2019).

light on little known, if not partly incognizable phenomena (see point a). Their formulation, therefore, necessarily contains arbitrary claims. Such claims are often disproved by further discoveries, or by taking into account already known, yet previously ignored, phenomena: 'A satisfactory system is built, while some facets of the phenomenon to explain are still ignored: as soon as these facets are discovered, the inadequacy of the reasons hitherto provided becomes visible, and the system collapses' (Maupertuis 1768b, 45). Ultimately, the pretension of building complete and accurate systems on generation, relying on scarcely known facts, is a mark of ignorance: 'If we believe to know anything, it is only because we are very ignorant' (Maupertuis 1768b, 45).

10.3 The Critique of Preexistence

The critique of the embryological models is accompanied by (yet separated from) a critique of the theoretical grounds of preexistence.⁷ The theory of preexistence was first formulated at the end of the seventeenth century. In his *Entretiens sur la métaphysique et sur la religion* (1688), Nicolas Malebranche departed from Descartes's account of the formation of the fetus (see Sect. 10.5 below), and claimed that 'all the parts essential to the machine of the animals and plants are so wisely disposed in their germs, that they will, in time and as a consequence of the general laws of motion, assume the shape and form which we observe in them'. This arrangement was established by God, who disposed the 'seeds' of plants and animals 'in the first days of the creation of the world, to grow insensibly and appear in due time' (Malebranche 1997a [1688], 176). Malebranche's approach is essentially mechanist, as he assumes that God has created the order of nature but leaves the world to be governed by natural (mechanical) laws, without further intervening in its evolution. As of animal generation, Malebranche denies that there might ever be any novel generation. In fact, God had put the germs of all future beings in Eve's ovaries (Malebranche is an ovist, while Adam's loins would be the spermatist alternative), which simply grow by the action of the laws of motion. As Malebranche stresses in the *Search after Truth* (1674),

We ought to accept [...] that the body of every man and beast born till the end of time was perhaps produced at the creation of the world. My thought is that the females of the original animals may have been created along with all those of the same species that they have begotten and that are to be begotten in the future (Malebranche 1997b [1674], 27).

In his presentation of the 'system of developments' (this is what he calls preexistence), Maupertuis singles out two major features of it. First, an extended application of the principle of analogy. Modern naturalists, Maupertuis argues, 'led by the analogy with what happens in plants, where the apparent production of parts is in fact the development of those same parts', believe that all generations can be

⁷Although Maupertuis's critique focuses on preexistence, he rejects any version of preformation.

reduced to ‘simple developments’ (Maupertuis 1768b, 64). The plant-animal analogy had been proposed by Malebranche himself, who had affirmed that ‘all trees are in the seeds of their seeds in miniature’, and that all these seeds ‘might contain other trees and other seeds, which will perhaps have on an incomprehensibly small scale other trees and other seeds and so to infinity’ (Malebranche 1997b [1674], 26–27; see also Roger 1963, 336). More generally, analogy was a basic principle for all theorists of preexistence, who had conducted studies on small insects or oviparous animals, and from there drawn conclusions on viviparous generation.

Second, according to Maupertuis, all advocates of preexistence think that it is ‘easier’ (Maupertuis 1768b, 64), namely theoretically more economic and simpler, to suppose that all animals are already existent since the beginning of time and simply need to develop into full-grown organisms, rather than to admit any novel production. The economy and simplicity of explanation, although Maupertuis does not explain it further, consisted in rejecting (1) the hypothesis of continuous creation, whereby nature would not be perfect from its creation but would rather need constant adjustments,⁸ and (2) the idea of the sufficiency of matter and motion (or other faculties that may be ascribed to matter) to explain the order of the world, that which would pave the way for materialism.

Maupertuis criticizes the use of analogy and the alleged economy of preexistence separately, expounding an empirical argument to contrast the first claim, and a theoretical argument to counter the second.

10.3.1 *The Empirical Argument*

In Maupertuis’s view, the analogy between the development of plants and animals is (at best) doubtful. Theorists of preexistence would for instance evoke the example of the tulip, whose bulb contains ‘the leaves and flower already formed’ (Maupertuis 1768b, 65) which only need to increase in size. The same, they say, applies to human beings, which are already fully formed before actual generation and only need to develop. Maupertuis makes two objections against this argument. First, the fact that in the tulip, as well as in humans, there is a moment when the organism is found fully formed and only needs growth (be it in the bulb or in the uterus) does not imply that there exists no former stage where the organism is not yet fully formed. In other words, nobody will deny that a baby is born a fully formed organism, but there might still be the possibility that the baby had not been fully formed since the beginning of fecundation. Second, even if it was the case that flowers as well as fetuses are preformed or preexistent, it is not clear on what grounds one could affirm that they are encased (*emboîtés*) the one inside the other, indefinitely. These two reasons lead Maupertuis to declare that the analogy between the generation of plants and animals is far from being demonstrated.

⁸On the idea of ‘continuous creation’ in early modern philosophy, see Pessin (2000).

The limits of analogy, however, are even more patent if one looks at the variety of generations in the animal kingdom: 'what a variety one can observe in the ways that different animal species perpetuate!' (Maupertuis 1768b, 52). There are animals, such as slugs, which are hermaphrodites. In their coitus, slugs encircle each other, and exchange sperm through 'long cords, which are their organs of generation' (Maupertuis 1768b, 57), alluding to their protruded genitalia. After this odd sexual encounter, both slugs lay eggs. Even more surprising are the phenomena of parthenogenesis, i.e. asexual reproduction, studied by Charles Bonnet in the 1740s, or the discovery of the peculiar reproductive methods of the fresh-water polyp made by Abraham Trembley in the same years (Dawson 1987). The fresh-water polyp, or *hydra vulgaris* (Fig. 10.3), a small freshwater animal, does not only reproduce through sexual contacts. In fact, this polyp can also reproduce through budding (a form of parthenogenesis): 'as branches grow from a tree, young polyps grow from another polyp: when those come to a certain size, they separate from the trunk that has produced them' (Maupertuis 1768b, 61). Yet the fresh-water polyp can even reproduce in a more surprising way, namely by regeneration. Trembley had in fact observed that, when a polyp is cut into segments, each one grows into another polyp. The reproduction of the fresh-water polyp, particularly through regeneration, challenged the mechanist view and suggested that 'a principle of life [is] diffused in every part of the animal' (Maupertuis 1768b, 63). More generally, the variety in the reproductive methods of animals very clearly shows the limits of analogy, thus undermining one of the main arguments in favor of preexistence.

10.3.2 *The Theoretical Argument*

Maupertuis addresses the question of the economy and simplicity of explanation that would characterize preexistence in a skeptical manner. It is true that the idea of a successive (read: epigenetic) development of organisms is not free from obscurity; but is the idea of a simultaneous creation of all living beings, contained the one in the other, more intelligible? According to Maupertuis, neither option is totally successful in clarifying the process of generation.

In fact, there are two possible ways in which to account for generation. On the one hand, one can explain reproduction through reference to material processes, without mentioning divine intervention. The champion of this approach is Descartes, 'this great philosopher,' who 'thought he could explain, only through the laws of motion and fermentation, how a heart, a brain, a nose, two eyes, etc. got formed' (Maupertuis 1768b, 67). On the other hand, one can refer to divine intervention to explain reproduction, as the theory of preexistence does. In case one considers God to intervene directly in the process of generation, one could assume that either He either created all beings at the beginning of time, or He created them at any time an act of generation takes place. Maupertuis argues that it is not clear what advantage would come from stating that the creation of all beings is simultaneous rather than

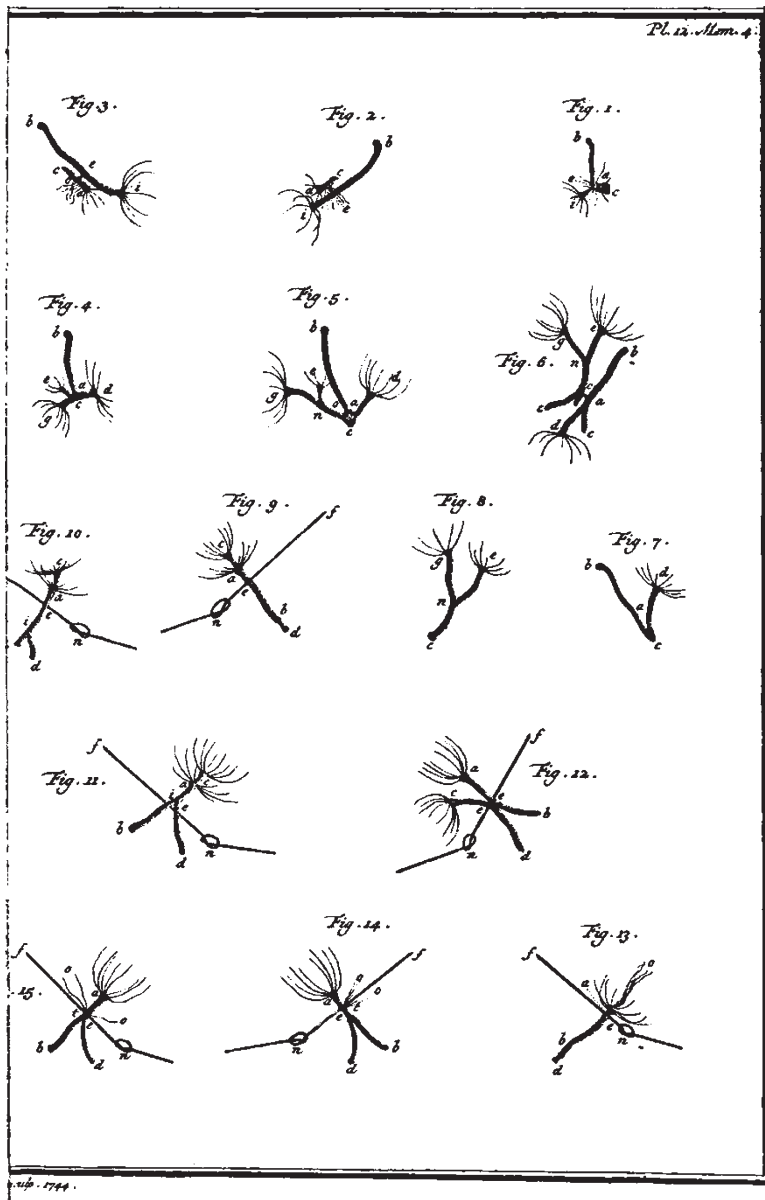


Fig. 10.3 Engraving from Abraham Trembley, *Mémoires pour l'histoire des polypes*. Wellcome Collection, London. Public Domain Mark

at different moments of history. After all, for God, events that we perceive as diachronic are synchronic, since He is not in time as we humans are.⁹

Two conclusions can be drawn from this argument. First, Maupertuis is skeptical about the very possibility of understanding completely the process of generation. Therefore, he regards any theory claiming to cast full light on it as highly pretentious. Second, Maupertuis introduces a hypothesis on generation, explicitly referring to Descartes, which he seems to judge more positively than the others: 'Descartes's opinion on the formation of the fetus [...] has something remarkable in it, which would be an argument in his favor if moral reasons mattered in this context' (Maupertuis 1768b, 67). On this model, as I will show in the following section, Maupertuis shapes his own theory of generation.

10.4 Maupertuis's Theory of Generation

The critique first of ovism and spermatism, and then of preexistence, prepares the terrain for advancing an alternative hypothesis on animal generation. Before introducing his theory, Maupertuis insists again on the obscurity of the subject, and on the uncertainty in which the naturalist might be caught: 'I know too well the faults of the systems discussed so far to embrace any of them: I find too much obscurity on this matter to dare propose a system myself' (Maupertuis 1768b, 80). Maupertuis presents in fact his theory as nothing else than a mere conjecture, and he has no pretense whatsoever of finding the ultimate truth on viviparous generation: 'I only have vague ideas which I propose as questions to discuss, rather than opinions to accept: I shall not be surprised, nor feel entitled to complain, if they are rejected' (Maupertuis 1768b, 80–81). Maupertuis's modesty has of course a rhetorical function, but is also a direct consequence of his skepticism about the very possibility of attaining an adequate knowledge of natural phenomena, and to construct a scientific view that will be universally accepted.

At the basis of Maupertuis's conjecture on generation are the ideas of epigenesis, which I have defined above, and the 'dual-seed theory'. According to the dual-seed theory, both men and women are endowed with testicles that produce seminal liquids. According to several Ancient medical texts, from the Hippocratic *Peri gonēs* to Galen's writings on the topic (Galen 1992, see also Boylan 1986), the testicles (masculine and feminine) convey organic particles from the body organs, which then contribute to the formation of the fetus. However dubious about the validity of the dual-seed theory, Maupertuis ends up embracing it:

Despite the alleged eggs, and the tiny animals which we observe in the seminal liquid, I am not sure that we should give up the Ancients' opinion on the way in which generation happens [...]. It is true that when we say that the fetus is made by the mixture of the two seeds, we are far from having explained this formation: yet the remaining obscurity is not to be

⁹The same argument is repeated in a further writing, namely Letter XIV '*Sur la génération des animaux*', published in the 1752 collection of *Letters*. See Maupertuis (1768b, 299–300).

ascribed to our way of reasoning. Whoever wants to know a distant object, and only uncovers it confusedly, has achieved a better result than those who see more distinctly but [look at] other objects than the one at stake (Maupertuis 1768b, 84–85).

Building on the dual-seed theory, Maupertuis expounds his hypothesis on viviparous generation. The organic particles contained in the seminal liquids convey in the uterus, and aggregate progressively by means of a force that drives those originating from the same organs towards each other:

Let there be, in each of the seeds, particles destined to form the heart, the head, the bowels, the arms, the legs; and let each of these particles have a greater relation [*rapport d'union*] to the one supposed to be united with it for the formation of the animal, more than any other; and the fetus will form (Maupertuis 1768b, 89).

Maupertuis cites one source for the notion of ‘relation’ or ‘*rapport d'union*’, namely Étienne-François Geoffroy’s 1718 *Table des différents rapports observés en chimie entre différentes substances*. In this text, Geoffroy claims that some chemical bodies have more affinity to combine than others, according to measurable degrees that could be fixed in a table. On the basis of his experiments, Geoffroy enunciates a general law according to which ‘every time two substances having some disposition towards each other are united, if a third one comes across them and has a stronger relation with one of the two, it will attach to it and make the other one let go’ (Geoffroy 1718, 203; see also Joly 2014). The same principle, according to Maupertuis, governs animal generation. A second possible source for this conception, although not quoted in the *Vénus physique*, is Newton’s gravitational attraction.¹⁰ Maupertuis explicitly identifies Geoffroy’s ‘*rappports*’ with the force of attraction: ‘I cannot but stress here that these forces and relations are nothing but what bolder philosophers call *attraction*’ (Maupertuis 1768b, 88).

The Newtonian flavor given to the account of generation is consistent with Maupertuis’s intellectual orientation, at least in the first part of his career (until 1745 and his move to Berlin).¹¹ As Jean d’Alembert recalls in the *Discours préliminaire de l’Encyclopédie* (1751), Maupertuis was in fact ‘the first who dared [...] declare himself openly Newtonian’ (d’Alembert 1751, xxix), particularly with the publication of the *Discours sur les différentes figures des astres* (1732) that includes a fierce defense of gravitational attraction (Storni 2020).

The epigenetic model proposed in the *Vénus physique* presents two major explanatory advantages with respect to preexistence, which Maupertuis discusses in detail. Since preexistence theorists endorse either ovism or spermatism, they are bound to support uniparental inheritance. How can they explain the resemblance, so often noticed, between an infant and both parents? The possibility to account for the biparental inheritance of characteristics is thus a first strength of an epigenetic and dual-seed theory of generation: ‘It is in this way [...] that the child is formed from the particles of the father and the mother, and often bears the visible traces of both

¹⁰Newton uses attraction to account for chemical phenomena in the famous *Query 31* of the *Opticks* (Newton 1952 [1730]).

¹¹On Maupertuis’s biography, see Beeson (1992) and Terrall (2002).

[parents]' (Maupertuis 1768b, 90). Maupertuis's theory seems to be further confirmed by some observations he had conducted in the same years on polydactyly in a Berliner family, the Ruhes, which he relates in his 1752 *Letters*. The surgeon Jacob Ruhe had six fingers on hands and feet, such as his mother Elisabeth Ruhen [*sic*] and her mother Elisabeth Horstmann. Three other children (out of eight) of Elisabeth Ruhen had the same feature, while her husband had five fingers. Now, Jacob Ruhe had married five-fingered Sophie-Louise de Thüngen; they had five children, two of which had six fingers. The trait was not perfectly transmitted, though: one of the two children, Jacob Ernest, had six fingers on the left foot, and five on the right foot; six fingers on the right hand (although he had the sixth cut off) and five plus a sort of wart on the left hand. On the basis of these observations, Maupertuis draws a first conclusion: 'polydactyly [*les sexdigitisme*] is equally transmitted by the father and the mother' (Maupertuis 1768b, 308). He also notices that there seems to be an underlying law regulating the inheritance of characteristics:

I think that nobody would regard the transmission of polydactyly as mere chance [...]. Yet if one considered the transmission of polydactyly as mere chance, one should consider what is the probability that this accidental variety be not transmitted by a parent to the offspring. After an inquiry I have conducted in a city with a hundred thousand inhabitants, I found out that two people had this feature [polydactyly]. Let us assume [...] that I missed three others, and that there is therefore 1 polydactylous person for every 20.000 people. The probability that their son or daughter will not be born polydactylous is of 20.000 to 1, and that their son or grandson will not be polydactylous is of 20.000 times 20.000, namely 400.000.000 to 1. Finally the probability that this singularity will not be transmitted across three generations is of 8.000.000.000.000 to 1: numbers so great that the certainty of the best demonstrations in physics do not come close to these probabilities (Maupertuis 1768b, 308–310).

The quantification of probability excludes that the inheritance of characters might be the result of pure chance and opens the possibility of thinking the modalities of transmission of phenotypes, which would have been impossible in the context of preexistence.¹²

The second major advantage of Maupertuis's epigenetic and dual-seed conception is the explanation of 'monstrous generations'. Two types of 'monsters' were commonly acknowledged in the eighteenth-century debate: the '*monstres par défaut*', namely mutilated organisms, and the '*monstres par excès*', viz. bodies with superfluous parts.¹³ The advocates of preexistence ought to admit that monsters were created as such by divine deliberation, while the supporters of epigenesis could argue that variations were caused by a casual arrangement of the organic

¹²Maupertuis is also considering other common hybridization phenomena such as the mule and the hinny, which are respectively the offspring of a male donkey and a female horse, and the offspring of a male horse and a female donkey. See Maupertuis (1768b, 163–164) and Glass (1947).

¹³In this sense, the members of the Ruhe family with six fingers would be 'monsters'. The term should therefore not be intended in the strict sense of an ugly and frightening creature, but rather as a deviation from the ordinary course of generation, which is defined according to empirical (and therefore purely contingent) criteria. On 'monsters' in the eighteenth century debate, see Moscoso (1998).

particles, without creating any theological embarrassment. Also, Maupertuis claims that the supporters of preexistence could not explain why superfluous parts in ‘*monstres par excès*’ are always located near the necessary parts: a sixth finger is always found on the hand, and never elsewhere. ‘Why will the monstrous germs respect this order in the location of their parts? Why are the ears never on the feet, nor the fingers on the head?’ (Maupertuis 1768b, 92).

In summary, the theory of generation developed in the *Vénus physique* naturalizes the process of generation, by explaining it in terms of natural forces and by minimizing the role of metaphysical reasons. From the scientific standpoint, while denying the role of eggs and spermatozoa in reproduction, Maupertuis’s explanatory model can account for variations, and creates the possibility of finding laws behind the phenomenon of transmitted phenotypes. On the theoretical level, the wariness with which the argument is expounded is not only due to the lack of experimental evidence, and to a rhetorical strategy to avoid critiques, but also to Maupertuis’s empiricist and skeptical approach which prevents him from hasty conclusions on such intricate questions.

10.5 The Question of Mechanism

The embryological model presented in the *Vénus physique* stands out for its use of the concept of affinity or attraction to explain generation but presents some elements of continuity with more traditional theories of reproduction, particularly Descartes’s mechanical account of generation. Scholars have mostly overlooked the connection with mechanism, which nonetheless seems important to understand Maupertuis’s argument, and its place in the history of eighteenth-century embryology.

In the *Description du corps humain* (1648, publ. 1664), Descartes had provided a description of the formation of the fetus, based on epigenesis and the dual-seed theory (Pyle 1987). According to Descartes, the fetus ‘produced ordinarily by the conjunction of the two sexes, seems to be but the indistinct mixture of two liquids’ (Descartes 1897–1910, XI, 253). These liquids heat each other by means of their motion, and progressively compose the embryo following a simple mechanical scheme: ‘their particles [of the liquids], acquiring the same agitation as fire, dilate and press the other ones, and by this means arrange them progressively in the way required to form the limbs’ (Descartes 1897–1910, XI, 253). Maupertuis expresses a positive judgment on Descartes’s account of generation, more positive than on Harvey’s (although this latter is a major source for the *Vénus physique*). A critical note, however, is represented by Descartes’s reliance on mechanical principles alone, which are not sufficient in Maupertuis’s view to explain viviparous reproduction.

Although I infinitely respect Descartes, and that I believe, like him, that the fetus is formed of the mixture of the two seeds, I cannot believe that one can be satisfied with the explana-

tion he provides, nor that an intelligible mechanics [*mécanique intelligible*] can account for how an animal is formed out of the mixture of two liquids (Maupertuis 1768b, 85).

Maupertuis's model of animal generation is essentially identical with the Cartesian one, except that, instead of purely mechanical forces, a relational force or force of attraction is introduced to explain the arrangement of the embryo parts. As a matter of fact, the Cartesian model is considered insufficient because no organization principle is ever mentioned that could account for the order of an organism. In the *Vénus physique*, Maupertuis proposes an 'updated mechanism' (Solinas 1967, 70), which traces a path from Descartes to eighteenth century epigenetic embryology, and paves the way for further upgrades of mechanism which will eventually lead to its dismissal.

I shall now investigate what role the reference to mechanism plays in defining the terms of the controversy with the theorists of preexistence. The late seventeenth and early eighteenth-century followers of Descartes's scientific approach were mostly unsatisfied with his explanation of animal generation. In this respect, the case of Malebranche is emblematic (Ferraro 2016, 14). Malebranche remained faithful to the mechanical approach to the study of generation, while rejecting the dual-seed theory and epigenesis in favor of ovism and preexistence. For Malebranche, preexistence could ground a metaphysical interpretation of the perpetuation of species that avoided the risk of ruling God out of the natural world, and of replacing an intelligent creator with mere mechanical laws or chance.

To contrast theorists of preexistence such as Malebranche, Maupertuis makes a double move. On the one hand, he reappropriates the Cartesian tradition by rehabilitating Descartes's own ideas on generation, while separating Descartes from the tradition of preexistence. Malebranche and his epigones would not be true Cartesians anymore, as they have betrayed Descartes's mechanistic view, at least on the question of generation.¹⁴ On the other hand, Maupertuis goes beyond Descartes by updating the Cartesian mechanist view with elements deriving from the new physical and chemical theories. Descartes's true heirs were not those who imagined human beings to be encased in each other's loins, following a metaphysical suggestion, but rather those who supported a progressive development of the fetus through natural causes – which were no more the laws of local motion and fermentation only, but forces seen at work in planetary revolutions and chemical reactions.

In short, while the supporters of preexistence were delegitimated in their appeal to the Cartesian view, the advocates of epigenesis working in the wake of Descartes were at the same time updating his 'strict mechanism', thus preparing the dismissal of the Cartesian paradigm in favor of a materialist approach.

¹⁴On the eighteenth-century reappropriations of Descartes, especially in the *Encyclopédie*, see Spallanzani (2009).

10.6 The Question of Generation after the *Vénus Physique*

In the introduction, I have mentioned that the *Vénus physique* is a key turning point in the gradual passage from the predominance of mechanism to the emergence of materialism in eighteenth-century French life sciences. In this sense, Maupertuis's 'updated mechanism' belongs in the 'middle ground' between the two paradigms.¹⁵ After the publication of the *Vénus physique*, a flourishing of epigenetic theories – strongly critical of preexistence and of the idea of the fixity of nature that preexistence entailed – is to be witnessed in the French-speaking world. Without overlooking the fortunes of preexistence up to the end of the century, as still supported by pre-eminent naturalists such as Albrecht von Haller, Charles Bonnet and Lazzaro Spallanzani (Roe 2003, 413–414), the epigenetic view, combined with the idea of the vitality of matter, became popular among materialists such as the Baron d'Holbach and Denis Diderot. The latter, in the article *Spinoziste* of the *Encyclopédie*, explicitly associates epigenesis with materialism (see Wolfe 2009, 2014). Matter, endowed with sensibility, is all that exists; nothing else is needed to explain the generation of an organism than sensible matter and its modifications:

Their [the Spinozists'] essential principle is that matter is sentient, that which they demonstrate [...] through the growth of every animal, which in its origin is but a point, and which by the nutritive assimilation of plants, in a word, of all substances serving as nutrition, becomes a large, feeling and living body existing in an extended space. From this they conclude that matter is all there is and is enough to explain everything (Diderot 1765, 474a).

An example of this post-1745 tendency to explain generation through material principles alone, while endorsing an idea of living matter over the mechanistic view, is Maupertuis's embryological work in the 1750s. In the *Système de la nature, ou Essai sur la formation des corps organisés* (originally published in 1751 as *Dissertatio inauguralis metaphysica de universalī naturae systemate* under the pseudonym Dr. Baumann, then edited in French in 1754), Maupertuis proves to be still critical of preexistence, which 'is rather to tell a miracle, than to provide a physical explanation' (Maupertuis 1768b, 145). In this text, Maupertuis abandons 'updated mechanism' because, as he now claims, 'a blind and uniform attraction, spread through all particles of matter, cannot explain how these particles arrange themselves to form even that body whose organization is the simplest' (Maupertuis 1768b, 146). The problem seems to lie in the fact that the principle of attraction is superimposed on particles and does not explain the reason why an arrangement is first produced, and then reproduces across generations. Maupertuis introduces therefore an alternative hypothesis, according to which the organic particles implied in generation have an inner principle of activity consisting in some basic psychic properties, which can explain the formation of organized structures: 'if we want to

¹⁵In the history of the life sciences, there is a tradition of a Cartesian-inspired 'expanded mechanism' that already exists in the late seventeenth century. See Des Chene (2005) and (on Descartes's physiology) Hutchins (2015).

¹⁶In the missing part of the quotation, Diderot refers to oviparous generation.

say something conceivable on this matter, although it is conceivable only by way of analogy, we have to resort to a principle of intelligence, to something similar to what we call *desire, aversion, memory*' (Maupertuis 1768b, 147). The theoretical framework has not changed from the *Vénus physique*: Maupertuis expounds his theory as a conjecture, given that the details of generation are precluded from direct experience, and the process is therefore describable only 'by way of analogy'. The claim Maupertuis makes is however radical, a lot more so than the mechanist and attractionist hypothesis put forward in the 1745 text. He argues in fact that 'no danger seems to come from the attribution to matter of some degree of intelligence, desire, aversion, memory' (Maupertuis 1768b, 149).

Maupertuis's attempt has been described as a spiritualization of matter (in a Leibnizian fashion) rather than the materialization of the soul (see Janet 1881; Wolfe 2010). The psychic properties of the small particles of matter are described in the language of the Leibnizian '*petites perceptions*', which contribute to the emergence of higher mental faculties as the particles enter in composition to form an organism (see Duchesneau 2013). Yet it is clear, as Diderot provocatively remarks in the *Pensées sur l'interprétation de la nature* (1753), that an eighteenth-century reader could perceive Maupertuis's theory as a 'most alluring kind of materialism' (Diderot 1753, LI, 156, cited in Wolfe 2010: 60).

Ultimately, the 1740s updating of the mechanist view opened the possibility of its critique, carried out by those like Maupertuis who had first proposed it, and eventually to its dismissal. The 'updated mechanism' was thus substituted by materialist positions, which entailed the idea of living and active matter, while remaining faithful to the epigenetic inspiration of the *Vénus physique* and strongly critical of preexistence.

10.7 Conclusion

In this chapter, I have presented the eighteenth-century controversy over animal generation through the lens of Maupertuis's *Vénus physique*. I have first discussed Maupertuis's critique of ovism and spermatism, and of preexistence, insisting on the empiricist approach that the savant adopts in the *pars destruens* of the text. I have also drawn attention to the theoretical stakes of Maupertuis's critique, where his skepticism clearly emerges. I have then moved on to presenting the theory of generation elaborated in the *Vénus physique*, questioning its relationship with the mechanist tradition. I have argued that Maupertuis reappropriates the Cartesian heritage, while updating Descartes's mechanical account of generation with elements drawn from modern chemistry and Newtonian physics. Lastly, I have shown that the theoretical framework and the naturalization of the explanatory model characterizing the *Vénus physique*, together with the reappropriation and updating of the mechanist view, pave the way for the emergence of materialist positions. A notable example of this can be found in the very development of Maupertuis's reflections, with the publication of the *Système de la nature* in 1751.

As a general result, I have highlighted the scientific and speculative interest, as well as the momentous historical relevance, of Maupertuis's discussion of animal generation in the *Vénus physique*, which stands out as a milestone in the history of the life sciences in the age of Enlightenment, particularly as a moment of transition between the hegemony of preexistence and the rise of a materialist approach.

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