# Biological Individuality, Pregnancy and (Mammalian) Reproduction

# Abstract

Mammals are usually considered unproblematic as biological individuals. This paper contends the opposite. Once we consider pregnancy, criteria for biological individuality are not easily applicable in mammals and give conflicting results: mammalian pregnancy poses a problem for biological individuality. This may open fruitful new approaches to biological individuality, and is of relevance to metaphysicians interested in (human) organisms.

# Keywords:

Organism, Biological Individual, Pregnancy, Mammal, Metaphysics, Reproduction

# 1. Pregnancy and the Problem of Biological Individuality.

What is the problem of biological individuality? Organisms[[1]](#footnote-1) are amongst the central entities with which the biological sciences are concerned. They develop, move, eat, fight, copulate and raise offspring; they have traits that biologists describe; and they are the entities that population biologists count. Even so it is not always clear which entities are organisms. In mammals, birds and reptiles things appear straightforward enough: here is a horse, there another. But in plants, insects and many other life forms, complications arise*.*Is the organism the individual ant or the ant colony? Is every individually rooted strawberry-clump a plant, or is the plant the entire patch stemming from one beginning? It is now well-described that biology lacks a single concept of or set of criteria for the organism that appears to give the correct, or even consistent answers to such questions across all taxa. This is the problem of biological individuality that, so far, has not been resolved. (Pradeu 2016b) No set of criteria have gained widespread support for delivering the right, or trustworthy, results across all of the natural world.

Even so this problem is generally discussed for life forms that appear very different from us: e.g. slime moulds; fungi; and eusocial insects. The contested case of their microbiome aside[[2]](#footnote-2), this is not generally considered a problem in mammals and other higher metazoans, such as birds and reptiles. These organisms remain easily and uncontroversially identifiable, both on the face of it, and in theory. Recently, however, I have suggested that pregnancy “presents a genuine and possibly novel set of questions for current debates surrounding biological individuality” in mammals. (Kingma 2019, 633)

I arrived at that position, not by considering biological individuality directly, but in the context of investigating the relationship between the fetus and the maternal organism. I drew upon four criteria for being an organism “frequently appealed to” (ibid) in philosophy of biology to argue that the fetus is part of the maternal mammal. Although I ultimately did not state that pregnancy poses a problem of biological individuality – a case where criteria for individuality give conflicting results – I did suggest very strongly that pregnancy makes the biological individuality of mammals much more complicated than it is generally taken to be.

This paper picks up where I left of in my (2019). It examines (1) whether pregnancy is indeed such a complicating case and (2) whether that results in a problem of individuality for mammals. There are at least two reasons for doing so. One is that it these are interesting questions, which I did not quite answer before. But, second, insofar as I did answer these questions, my earlier attempt can be improved upon: two of the four criteria I used in Kingma (2019) – physiological autonomy and functional integration – are amongst the four rejected by Clarke (2010) as serious candidates for defining biological individuality (even in the context of Clarke’s otherwise very permissive approach).[[3]](#footnote-3) We can, and will, do much better than that. In section two I test my suggestion by applying eight criteria for biological individuality to the entities involved in mammalian pregnancy. Section three concludes and identifies questions for further work.

The problem of biological individuality is already well-described. This paper makes an important contribution in critically questioning assumptions we tend to make about so-called ‘easy’ cases: mammals. This is, first, of special relevance to us: we are mammals. If there is no single account of what the mammalian organism is, then this is not just important for (the philosophy of) biology, but also for other branches of philosophy: for example for animalists who defend the claim that we are animals (Olson 1997; Snowdon 2014), or metaphysicians who wish to question when human organisms begin (e.g. Smith & Brogaard 2003). Second, pregnant mammals – a life form that is very familiar to us – may help us investigate the problem of biological individuality in new and fruitful ways. Third, the paper extends questions about biological individuality to gametes. This suggests that biological reproduction in higher metazoans in general may incur problems of biological individuality. That warrants further research.

# 2. Testing Pregnancy against Criteria for Biological Individuality.

Clarke (2010) gives an overview of 13 criteria that appear to be – and have been used or defended as – serious contenders for defining biological individuality. She applies some of these criteria to six candidates for being a biological individual, which on intuitive – or, rather, naïve or first – appearances range from parts of organisms (a lobster’s claw) to groups of organisms (a bee colony). Clarke uses this exercise to demonstrate that the criteria give different, non-overlapping verdicts for these different candidates, concluding that the problem of biological individuality is a genuine problem.

I use Clarke’s exercise to a slightly different end: by applying a selection of her criteria to different candidate entities involved in mammalian reproduction, I show that some of these candidates also constitute problem cases, as different criteria generate different results. This is interesting because in her original exercise, Clarke returned the verdict that mammals are wholly unproblematic[[4]](#footnote-4): “the puppy passed every single test.” (Clarke 2010, 322)

The entities that I will consider are the following: First, and for comparison, the male puppy that Clarke considered a prime example of a

“paradigmatic higher metazoan […]. The[se] share with humans all of the features that have been historically taken to be reliable hallmarks of individuality. Any definition [of biological individuality] that excludes this example will be strongly counterintuitive.” (Clarke, 2010, 321)

Second, a gamete: a (canine) sperm or egg cell. This is included because, in the course of applying this exercise, I came to realise that gametes too seem to be problematic. Since our interest here is in reproduction by pregnancy, and gametes are key entities involved in mammalian reproduction, it is apt to include them.

Third and fourth, a fetal dog and a pregnant dog. These are included because they appear to be the central entities involved in (canine) pregnancy, which I suggested presents problems for biological individuality in mammals (Kingma 2019). But in that paper I also noted an important question about pregnant dogs: does the pregnant dog include or exclude the fetal dog(s) it gestates? Which answer we take to be true affects how pregnant dogs fare against the different criteria in this exercise. Because I want to remain non-committal in this paper about the correct answer to my (2019) question, we shall consider both possible understandings of pregnant dogs: PDinc for the pregnant doc *inclusive* of the fetus and PDex for Pregnant Dog *exclusive* of the fetus.[[5]](#footnote-5)

I apply to these candidates only a subset of Clarke’s (2010) 13 criteria of individuality before summarising the results in figure 1.[[6]](#footnote-6) For each of these criteria I give no more than a brief introduction; more detail and references can be found in Clarke (2010). Following Clarke, I don’t defend the criteria, or my application of them. The merit of the exercise is in raising the question and taking a first stab at answering it, in a way that can form the basis for further discussion.

Figure 1: Application of 8 criteria for biological individuality to 5 candidate entities in the mammalian lifecycle.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Puppy | Gamete | Fetus | PDex | PDinc |
| 1. Genetics | Y | Y | Y | Y | N |
| 2. Spatial Boundary | Y | Y (?) | N | N | Y |
| 3. Sex | Y | N | Y | Y | N |
| 4. Bottleneck | Y | Y | Y | Y | N |
| 5. Immunity | Y | N | N | N | Y |
| 6. Germ-Soma Separation | Y | N | Y | Y | Y (?) |
| 7. Policing Mechanisms | Y | Y | Y | Y | Y |
| 8. Fitness Maximisation | Y | N (?) | Y | Y | Y (?) |

## 2.1 Genetics

According to this criterion, biological individuals have unique or homogeneous genotypes, so that their parts are maximally related. Of our five candidates, the gamete, the puppy, PDex and the fetus all have genotypes that are sufficiently homogeneous to meet this criterion.[[7]](#footnote-7) The clear exception is PDinc, which is not homogeneous; the fetal and maternal portions are genotypically only 50% related.

## 2.2 Spatial Boundaries

According to this criterion, biological individuals should be “physiologically discrete”, “spatially bounded” and/or “spatially localised”. (Clarke 2010, 318). The puppy is physiologically discrete and spatially bounded, as is PDinc. But the fetus is not: it is physiologically integrated in the maternal organism and spatially indistinct from it. Granted, the fetus has boundaries such that we can distinguish it from other parts of the PDinc – but so does your kidney. The point is that, like the kidney, it is not completely physiologically or topologically demarcated: through the umbilical cord and placenta there is a direct topological and physiological connection. (Kingma, 2018; forthcoming)[[8]](#footnote-8) Nor, and for the same reason, is the PDex spatially bounded and physiologically discrete: it is with respect to most other mammals, but not with respect to the fetus.

The gamete is a bit more difficult to judge. On the one hand it has a complete, external boundary: its cell membrane. On the other hand, the egg remains inside the parental body. On another hand again, the sperm does not remain in the parental body, and the egg could be moved to a petri-dish. On yet another hand, we could perhaps say of the individual sperm that it is physiologically integrated in the seminal fluid that also contains other sperm, nutrients, and so on.[[9]](#footnote-9) All of this motivates me towards a tentative yes only, and a ‘yes’ that it is a bit more confident for the sperm than it is for the egg.

## 2.3 Sex

According to this criterion, the biological individual is all of the mitotic[[10]](#footnote-10) product of a sexually fertilised zygote. This applies to the puppy, PDex and the fetus. PDinc is excluded by this criterion as it is the product of two (or more) different sexual events: one for the mother; one (or more) for the fetus(es).

Gametes are not the mitotic product of a sexual event, but the (eventual) meiotic product of one, and the ingredient for a new zygote. They are therefore excluded by this criterion. Note the implication of this: gametes are not part of the adult organism (for they are not part of the *mitotic* product of a sexual recombination event).

## 2.4 Bottleneck

According to this criterion, the biological individual is the mitotic product of a bottleneck stage in the lifecycle, in which the organism effectively ‘shrinks down’ to just one – or a few – cells. In mammals that bottleneck is the zygote; this criterion thus gives the same result as sex. With one exception: the gamete also appears to be an individual on this view. For meiosis – the process by which diploid cells form haploid gametes – produces a bottleneck; the gamete *is* this bottleneck.

## 2.5 Histocompatibility or Immunity

According to this criterion, parents are distinguished from other organisms, including their offspring, by immune responses. Or, to follow a recent refinement of this view: biological individuals are characterised by the continuity of ongoing immunogenic interactions between their parts. (Pradeu 2010; 2012)

The puppy is straightforward: it meets this criterion, as does PDinc. “Mammals are actively set up so that, on the whole, the foster[[11]](#footnote-11) is not attacked by the gravida’s[[12]](#footnote-12) immune system during pregnancy. [..] And this active immunological non-rejection signals acceptance by the gravida of the foster as one of its parts (Pradeu 2012; Howes 2007).” (Kingma 2019, 629) It follows that the PDexis not a biological individual; it does not distinguish itself from the fetus. I suspect this means that the fetus does not sufficiently distinguish itself from its mother either, but I do not know whether the fetus should be thought of as having its own immune response at all.

I am not completely confident about the application of this view to gametes; Pradeu (2012) has a very broad concept of the immune system that allows for its application to unicellular life. This means we could consider the oocyte and sperm as having something that counts as an immune response; evidence of selection amongst sperm by the oocyte is an example. But there is also immunogenic interaction between the maternal organism and its oocytes. This appears to suggest the latter are part of the former. Sperm may then become part of the maternal organism, either, and transitively, due to immunogenic interaction with the egg, or directly though immunogenic interaction within other parts of the mother’s reproductive tract. The sperm (at least until the point of leaving[[13]](#footnote-13)) was part of the parental organism.

## 2.6. Germ-Soma separation

According to this criterion, the biological individual has a reproductive division of labor so that some cells are sterile and carry out only somatic functions, whereas other cells contribute genetic material to the next generation: the germ-line. This is true for the Puppy, PDex and the fetus (except, if we wish to be precise, the very early stages of the embryo when there is not yet a germ-soma division). All of these have sterile somatic cells and a germ line. This criterion excludes gametes, which are all germ-line.

I am not entirely sure what this criterion says about the PDinc. Strictly speaking this has a division between sterile parts and germ-line. It is just that it has two germ lines: one in the ovaries; one in the fetus’ ovaries/testicular buds. One might think this rather undermines the spirit of the view, which – perhaps – was about having *one* germ line. But another way of thinking about it is that the fetus, including its germ-line, *is* still part of mother’s germ line – after all, it directly grew out of her germ-line. On that view we get a nesting of germ-lines. On the whole, then, I think the answer is yes, but I am less confident than I am about the other verdicts.

## 2.7. Policing Devices

According to this criterion, biological individuals possess ‘policing devices’, ‘anti-subversion devices’; or ‘conflict modifiers’. There is room for disagreement on how precisely to apply this criterion to our cases, which I cannot fully address here. On the face of it, the gamete has policing mechanisms – it holds itself together so that, for example, the potential intra-genomic conflict between its nuclear and mitochondrial DNA is suppressed.[[14]](#footnote-14) The puppy, PDex and fetus also have policing mechanisms: some of the mechanism we already discussed, such as germ-soma separation and the immune system, function as such devices. The existence of controlled cell apoptosis is another example; this prevents cells from ‘defecting’ and reproducing uncontrollably (e.g. as cancer).

The PDinc also has several such mechanisms – if only because the PDex and fetus, of which it is composed, possess them. But surely the key question for this entity is whether it is policed in its entirety – which would make it an individual – or whether only its fetal and ‘PDex’ parts are policed separately, which makes it a (tiny) group? There is certainly some evidence of the former: in many mammals the mother can selectively abort or reabsorb fetuses or control their early development. This controls and suppresses the conflict that she faces from having different genomes within her. For the fetus – or at least the paternal half of its genome – rarely has an interest in being reabsorbed[[15]](#footnote-15). Its mother and the maternal part of its genome more often has such an interest: the circumstances under which reabsorption is (statistically) preferred, are different for the maternal and paternal parts of the fetal genome. (Haig 1993) By retaining some control of the fetus, the PDinc effectively polices these potentially conflicting interests within her. As I wrote elsewhere: “(g)iven the genetic heterogeneity involved in the case of the foster and the gravida, the high degree of successful regulation and suppression of competition between them—itself a key indicator of organismic individuality—is what stands out as particularly impressive.” (Kingma 2019, 627) That said, this is a first judgment; I suspect a lot more can be said about this criterion than I have space for here.

## 2.8 Fitness Maximisation

According to this criterion, a biological individual is a unit whose parts are all under selection to maximise the unit’s inclusive fitness. With the exception of the puppy, which gets a clear ‘yes’, this criterion is not easy to apply in our cases. Take gametes first. One could argue that all parts of the gametes are under selection to maximise the fitness of the gamete. But one could also argue that gametes are under selection to maximise the fitness of the organism of which they are gametes.[[16]](#footnote-16) I’ll go with the latter, but a question mark too.

It is even less clear what this view says about the fetus, the PDinc and the PDex. There are certainly ways in which the parts of the fetus and PDex are under selection to maximise the fitness of the respective whole. But now take the placenta – and suppose this is at least a part of the fetus. This part is not *just* under selective pressure to maximise the inclusive fitness of the fetus; it is also under selective pressure to maximise the inclusive fitness of the PDex. The inclusive fitness of the fetus alone demands that the placenta is slightly more invasive, claiming more of the maternal resources than the mother (in fitness-maximising terms) wants to give. But the inclusive fitness of the mother demands that the placenta is slightly less invasive, leaving more of her resources for other offspring. We know that both these evolutionary pressures play out in the placenta. (Haig 1993) We also know that depending on life history, these pressures have resulted in different forms of placentation in different mammalian species. (Garrat et al. 2013). One way of understanding what goes on here is that parts of the PDex and fetus are under selective pressure to promote the inclusive fitness of all of the PDinc. This suggests that the PDinc as a whole – as well as the fetus and the PDex – undergoes selection to maximse the unit’s inclusive fitness.

But another way of viewing this is that the placenta is a part either of the fetus or the PDex that facilitates a particular form of cooperation between fetus and PDex, just as a flower is a part of the plant that promotes cooperation with bees, in a way that promotes its inclusive fitness.

I am inclined to give all candidates a yes, but this is an initial judgment only. This is a criterion on which much more can – and hopefully will – be said than I have space for here. I t confirms my earlier judgment that considerations such as these “take(s) us straight to the heart of contemporary debates over levels of selection, biological individuality and the nature of organisms”. (Kingma 2019, 632).

# 3. Conclusion and Further Questions.

What can we conclude from all this? First, that there is a problem of biological individuality, not just for more ‘exotic’ (from our perspective) life forms, but for those that are most familiar: mammals.[[17]](#footnote-17) As figure 1 illustrates, different criteria give different answers: read horizontally, our first seven criteria for biological individuality give six different distributions of Y/N over our five candidate entities. Only ‘genetics’ and ‘bottleneck’ give the same result. Read vertically, this leaves the biological individuality of all but one of our candidates in some doubt; only he puppy appears to stand unassailed, consistent with Clarke’s earlier (2010) verdict. Until we remember that – of course – puppys were once fetuses, and pregnant dogs were once puppies. Further consideration of that point will have to await future work. Meanwhile considerations of mammalian reproduction should at least be considered alongside other so-called problem cases in the literature on biological individuality, and may offer new and fruitful ways of evaluating them.

Second, the application of these criteria was not always straightforward. Clarke wrote: “Higher metazoans are in general relatively easy to individuate, most tests agree on their individuation, and give or take a few worries about parthenogenesis or regenerative abilities, there aren’t real problems regarding these organisms.” (2010, 323) But whereas all criteria were indeed easy to apply to puppies, considering the entities involved in pregnancy resulted in real difficulties for applying some of these criteria. In particular, ‘policing mechanisms’ and ‘fitness maximisation’ could in some cases be argued to go either way.[[18]](#footnote-18) The application of these criteria in mammalian pregnancy is therefore less straightforward than we might have thought, and stands in need of further work.

Third, what are the implications for my (2019) question about the mereological relationship between the fetus and the maternal organism? Some of the present results appear to have direct bearing on it. In Kingma (2019) I argued that the fetus is a part of the maternal organism, according to four criteria for biological individuality. Criteria that recognise the PDinc, but not the PDex, as an organism appear to corroborate that view. They effectively decree that the fetus is part of the pregnant organism. (These criteria are ‘spatial boundaries’ and ‘immunity’, both of which were discussed in my (2019)). But others count against my (2019) claim: those that recognise PDex, but not PDinc as an organism decree that the fetus is not part of the maternal organism. (These are ‘genetics’, ‘sex’ and ‘bottleneck’). The remaining criteria appear to underdetermine my (2019) question; both the PDinc and PDex lay claim to being an organism, which leaves open the question which is *the* pregnant dog. Many of these criteria warranted further discussion, however, as their application was itself difficult to judge.

What is also notable is that, if we read the table vertically, the fetus and the PDinc get the same result for all criteria: where one is denied individuality, so is the other; and where one is granted individuality, the other is too. This may suggest that the fetus is not an individual on these criteria only when (or because?) it is taken to be part of the PDex. That suggestion needs further defence. It also stands out that that the fetus and the gamete do not get the same results, even though both, arguably, are the maternal organism’s effort at starting a next generation. I emphasise once again that this is an initial result. A more detailed treatment of these criteria is needed. Indeed, some of the judgments made about the application of these criteria are not independent of an answer to my (2019) question about the metaphysics of pregnancy. For it seems that for some criteria, such as spatial boundaries and, perhaps, fitness maximisation, either the PDinc or the PDex– but not both – could be a biological individual.[[19]](#footnote-19) The resolution of some question marks in figure 1 may thus necessitate judgment on one of the other candidates. The correct application of some criteria may then depend on which is, ultimately, the pregnant dog – and *this* depends on whether the fetus is or is not part of the pregnant organism. If that in turn is to be determined by the correct application for some criteria of biological individuality, then we may be led into a circle. This means that a resolution of the metaphysics of pregnancy, in the way I approached it in my (2019), and the problem of biological individuality in mammals, may have to be considered jointly.

Fifth, and finally, gametes lay claim to being an individual/organism on several of the criteria above. The application of some of these criteria also contradicts our ordinary idea that gametes as part of the parental organism (at least until they are ‘expelled’). A further complication, as we saw, is that egg and sperm may not fare exactly the same on all criteria. These matters warrant further research. If gametes are in fact individuals then this suggests – not wholly implausibly – that reproductive efforts may raise complications about biological individuality in higher metazoans more generally, with or without pregnancy. We are already familiar with some such problems in the context of distinguishing reproduction and growth in asexual reproduction. (Janzen 1977) Some of the issues described here, then, are prompted by, but may not be restricted to, mammalian pregnancy.[[20]](#footnote-20)

***References***

Chan, William F.N., Cécile Gurnot, Thomas J. Montine, Joshua A. Sonnen, Katherine A. Guthrie, J. Lee Nelson. “Male Microchimerism in the Human Female Brain.” *PLOS One* 7(9): e45592. https://doi.org/10.1371/journal.pone.0045592

Clarke, Ellen. 2010. “The Problem of Biological Individuality.” *Biological Theory* 5:312-325.

––– 2012. “Plant individuality: a solution to the demographer’s dilemma.” *Biology and Philosophy* 27: 321-361.

––– 2013. “The multiple realizability of biological individuals.” *The Journal of Philosophy* 110: 413-435.

Dupré, John and Maureen O'Malley. 2009. “Varieties of Living Things: life at the intersection of lineage and metabolism.” *Philosophy and Theory in Biology* 1:1-25.

Garrat, Michael, Jean-Michel Gaillard, Robert C. Brooks, Jean-François Letmaître. 2013. “Diversification of the eutherian placenta is associated with changes in the pace of life.” *Proceedings of the National Academy of Sciences* 110:7760-7765.

Haig, David. 1993. “Genetic conflicts in human pregnancy.” *Quarterly Review of Biology* 68:495-532.

Howes, Moira. 2007. “Maternal Agency and the Immunological Paradox of Pregnancy.” In *Establishing Medical Reality: Essays in the Metaphysics and Epistemology of Biomedical Science*, ed Harold Kincaid, and Jennifer McKitrick, 179-198. Dordrecht: Springer.

Hutter, Thiago, Carine Gimbert, FrédéricBouchard, and François-Joseph Lapointe. 2015. “Being Human is a Gut Feeling.” *Microbiome* 3:9.

Janzen, Daniel H. 1977. "What Are Dandelions and Aphids?" *The American Naturalist* 111:586-589.

Kingma, Elselijn. 2018. “Lady Parts: The Metaphysics of Pregnancy.” *Royal Institute of Philosophy Supplement* 82:165-187.

––– 2019. “Were you a part of your mother? The Metaphysics of Pregnancy.” *Mind* 128:609-646.

––– (forthcoming) “Nine months.” *The Journal of Medicine and Philosophy* -:--.

O’Donoghue, Keelin. 2008. “Fetal microchimerism and maternal health during and after pregnancy.” *Obstetrical Medicine* 1:56-64.

Olson, Eric. T. 1997, *The Human Animal: Personal Identity without Psychology.* Oxford: Oxford University Press.

Pradeu, Thomas. 2010. “What Is an Organism? An Immunological Answer.” *History and Philosophy of the Life Sciences* 32:247-267.

––– 2012. *The limits of the self: immunology and biological identity*. Oxford: Oxford University Press.

––– 2016a. “Organisms or biological individuals? Combining physiological and evolutionary individuality.” *Biology and Philosophy* 31:797-817.

––– 2016b. “The many faces of biological individuality.” *Biology and Philosophy* 31:761-773.

Skillings, Derek. 2016. “Holobionts and the Ecology of Organisms – Multi-Species Communities or Integrated Individuals?” *Biology and Philosophy* 31:875-892.

Smith, Barry and Berit Brogaard. 2003. “Sixteen Days.” *Journal of Medicine and Philosophy* 28:45-78.

Snowdon, Paul. F. 2014. *Persons, Animals, Ourselves.* Oxford: Oxford University Press.

1. I use terms ‘biological individual’ and ‘organism’ interchangeably. Not everyone agrees with that usage (Pradeu 2016a) but my terminology is consistent with that of Clarke (2010, 2013). [↑](#footnote-ref-1)
2. Some argue that the close cooperation between higher metazoans and their symbiotic bacteria should cause us to view the multi-species ‘holobiont’ as the organism (Dupre & O’Malley 2009; Hutter et al. 2015) Others disagree (Queller & Strassman, 2016; Skillings, 2016 ). [↑](#footnote-ref-2)
3. I am grateful to Jonathan Grose for alerting me to this. In my defence defence, Clarke does not consider these criteria to be irrelevant; rather she considers them to be too vague. Any usefully fleshed out notion of them is subsumed under one of her other criteria. [↑](#footnote-ref-3)
4. This verdict is in conflict with some discussions about holobionts and the microbiome (footnote 2). Perhaps this is unsurprising: Clarke’s interest is primarily in counting individuals (Clarke 2010, 2012, 2013). Whether the puppy is a multi-species holobiont or only composed by mammalian cells, in either case there is only one puppy bouncing around the living room. [↑](#footnote-ref-4)
5. If my (2019) ‘parthood view’ of the relation between a gestating organism and its fetus(es) is correct, then PDinc is the dog, and PDex is the dog minus the fetus(es). If not, PDex is the dog, and PDinc is the sum ofthe dog and the fetus(es). [↑](#footnote-ref-5)
6. The subset was chosen based on ease and interest of application. Since my conclusion is that they give varied results, rather than that they show a particular result, applying a subset is not a problem: the conclusion does not depend on my cherry-picking these criteria. [↑](#footnote-ref-6)
7. The idea that they are completely homogeneous is a myth. Due to processes such as mutational build-up with age and microchimerism (Chan et al. 2012; O’Donoghue 2008). there exists variation amongst the cellular genomes in a mammal’s body. The order of homogeneity is: gamete > fetus > puppy > PDex. [↑](#footnote-ref-7)
8. Note also a prescient Clarke (2010, 321) on spatial boundaries: “The puppy easily passes this test after it has been born, though not before.” [↑](#footnote-ref-8)
9. I am grateful to Jonathan Grose for helping me think more carefully about gametes. [↑](#footnote-ref-9)
10. Mitosis, in lay-terms, is ‘normal’ cell division. This is to be contrasted with meiosis, which is a special, gamete-producing form of cell-division (that halves the number of chromosomes in the cell). [↑](#footnote-ref-10)
11. ‘Foster’ is my (2019) term for all of the pregnant material – which here we can treat as indicating the fetus. [↑](#footnote-ref-11)
12. ‘Gravida’ is my (2019) term for the pregnant mammal. [↑](#footnote-ref-12)
13. But see my earlier comment on the relationship between individual sperm and the surrounding seminal fluid. [↑](#footnote-ref-13)
14. Mitochondrial DNA is only transmitted to the next generation by females. This means nuclear and mitochondrial DNA have different evolutionary interests: the nuclear DNA in an oocyte does not care whether it combines with an X- or Y-chromosome carrying sperm. But mitochondrial DNA will only be passed down the generations if the oocyte pairs up with an X-carrying sperm, and therefore has an evolutionary interest in doing so. [↑](#footnote-ref-14)
15. One might think it never has such an interest, but that is incorrect if we consider inclusive fitness: where partner fidelity is high or multiple fetuses are fathered at once, this particular fetus’ reabsorption could benefit contemporary or past/future siblings that share 50% of the same paternal (as well as maternal) genome. [↑](#footnote-ref-15)
16. For example because the sperm originating in one male cooperate in competition with the sperm from other males. [↑](#footnote-ref-16)
17. If one takes the gut microbiome to already generate one such problem, then this is a further one. [↑](#footnote-ref-17)
18. Problems also arise for two of Clarke’s (2010) criteria I did not discuss: adaptation and conflict/ cooperation. “The organism must display adaptations at the level of the whole that are not present at the level of the components.” (Clarke: 2010: 320) But whose adaptation is the placenta? As for conflict/cooperation: the presence of both conflict and cooperation between fetus and pregnant organism makes this, too, difficult to assess. [↑](#footnote-ref-18)
19. This may also be the case for some of Clarke’s (2010) criteria that I did not discuss, such as conflict/cooperation. [↑](#footnote-ref-19)
20. I am grateful to Ellen Clarke, all members of the BUMP project group – Teresa Baron, Suki Finn, Alex Geddes, Anne Sophie Meincke, Ziggy Schilpzand and especially Jonathan Grose – and organisers. participants and audiences at the following occasions – for helpful discussion and advice on the ideas expressed in this paper. Symbiosis Workshop, Exeter, UK, Nov 2015; PhilBioUK Conference, Bristol, UK, June 2016; Visiting Speaker Talk, Dpt of Philosophy, Leeds, UK, February 2018; Metaphysics of Pregnancy Symposium at the BSPS conference, Oxford, UK, June 2018; Metaphysics of Mammalian Reproduction Symposium, PSA conference, Seattle, USA, Nov 2019.

    This paper is part of a project, “Better Understanding the Metaphysics of Pregnancy”, that has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme, under grant agreement number 679586. [↑](#footnote-ref-20)