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Human organisms begin to exist at fertilization

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Abstract

Eugene Mills has recently argued that human organisms cannot begin to exist at fertilization because the evidence suggests that egg cells persist through fertilization and simply turn into zygotes. He offers two main arguments for this conclusion: that 'fertilized egg' commits no conceptual fallacy, and that on the face of it, it looks as though egg cells survive fertilization when the process is watched through a microscope. We refute these arguments and offer several reasons of our own to think that egg cells do not survive fertilization, appealing to various forms of essentialism regarding persons, fission cases, and a detailed discussion of the biological facts relevant to fertilization and genetics. We conclude that it is plausible, therefore, that human organisms begin to exist at fertilization – or, at the very least, that there are grounds for thinking that they existed as zygotes which do *not* apply to the prior egg cells. While this does not entail that human persons begin to exist at this point, it nevertheless has considerable significance for this latter question.

KEYWORDS

abortion, beginning of life, fertilization, identity, life, organisms, personal identity

1 | INTRODUCTION

One common pre-theoretical view of human beings is that we are so intimately related to organisms that our existence is ordinarily temporally co-extensive with that of our organism. This intimate relation might be identity, constitution, association of a soul, or some other view. We also take it that the predominant pre-philosophical position[1] is that sexually reproducing organisms (typically) begin to exist as a direct result of sexual reproduction between two parent organisms, when the two reproductive cells from each parent meet to form a genetically distinct zygote. On this conjunction, then, it is highly likely that individuals like you and I begin to exist at the same moment as the organism comes into existence – namely, at fertilization.

The first view is held by animalists[2] who hold that we are *identical* with or constituted by our organisms, by hylomorphists[3] who think we are ordinarily compounds of form and matter, with the form being responsible for our being organisms, and by those substance dualists who think that the soul comes into existence at the same time as the organism does.[4] By being restricted to the *ordinary* course of things, this view remains neutral on questions of whether we could come to live in a computer instead or whether a supernatural being could give us an afterlife after the destruction of our bodies.

In any case, we often take an organism's surviving through time to be strong evidence that the person associated with that organism survives through time. And we generally take evidence that persons

[1]We were initially inclined to call this 'the common-sense position'. We appreciate, however, that there is sufficient disagreement to preclude assuming this at this stage. We recognize that legal precedent – in the UK at least – has now been clarified against this view. But we do not thereby intend to underplay the ostensible pre-philosophical support for this thesis: our experience is that in the absence of ideological or political context, many (perhaps most) laypeople who have no pro-life commitments will say that fertilization marks the beginning of an organism. Our primary interlocutor, Eugene Mills, himself indicates that this view has 'wide acceptance' see Mills, E. (2008). The egg and I: Conception, identity and abortion. *Philosophical Review*, *117*, 332, though he thinks that its wide acceptance is misplaced and that it does not lend the view any support. We wish to emphasize that this view is, similarly, commonly found in biology textbooks in the absence of ethical or ideological considerations, as we show later. Indeed, religion and ethical opposition to abortion long antedate the discovery of the details of fertilization and make no detailed claims about when human organisms or persons begin to exist. So we suggest that the best explanation of the fertilization view is that it arose out of biology before being adopted by prolifers and religious proponents, and that the thesis enjoys considerable currency in the history of biological thought. We do not wish to press this too forcefully, however, since our argument in no way depends on it.

[2]E.g. Olson, E. T. (1997). *The human animal: Personal identity without psychology*. New York, NY: Oxford University Press.

[3]E.g. Oderberg, D. S. (2007). *Real essentialism*. New York, NY: Routledge.

[4]We do not hereby imply that these options are the only ones entailing temporal co-extension of organism and person: there may be further variants. But these are the most common ones and we trust that the reader is able to extend our arguments accordingly.

x and *y* are, or are relevantly associated with, the same organism to be evidence that *x* and *y* are the same person. There are ordinary and intimate links between organisms and people such that asking questions about an organism's survival and an organism's identity often tells us a considerable amount about the person related to that organism. We note that while our thesis does not show that human *persons* begin to exist at fertilization, it goes some way toward substantiating that view in conjunction with other theses advanced elsewhere.

Questions about our identity, and hence about the identity of organisms, are important to beginning- and end-of-life issues in applied ethics. And the identity of organisms is important for other reasons in ethics – for those who think that species-membership guarantees certain rights, for example. But even supposing that the question is ethically unimportant, we note that it is still an interesting theoretical question within metaphysics and the philosophy of biology.

Eugene Mills[5] has recently challenged the view that we begin to exist at fertilization[6] by arguing that *organisms* do not begin to exist at fertilization. Either we once were zygotes[7] or we were not, argues Mills. If we were not, then we did not begin to exist at fertilization. If we were, then we probably also existed as egg cells before fertilization. But if we existed as egg cells, then we did not begin to exist at fertilization.

Against those who hold that organisms begin to exist at fertilization, Mills' argument therefore depends on the following claim:

> (EZ-identity) Egg cells are identical with the zygotes which they cause to exist.

Mills marshals several arguments in support of this thesis. These involve direct arguments for EZ-identity, as well as objections to the common reasons for denying EZ-identity.

We shall argue that EZ-identity is false, first by taking on Mill's arguments for EZ-identity, and then by arguing directly against EZ-identity. By making this argument, we will refute one of the more important objections to the view that we begin to exist at fertilization.

2 | POSITIVE ARGUMENTS FOR EZ-IDENTITY

2.1 | The terminological argument

Mills' first argument for EZ-identity is terminological. He writes:

> A zygote is a fertilized egg. A fertilized egg doesn't pop into existence upon fertilization; it exists, unfertilized, before its encounter with the fertilizing sperm.[8]

The obvious objection to this argument is that fertilized eggs are not really eggs in the technical, biological sense at all. Mills notes this objection, giving the examples of crowned princes and victorious candidates in support of it. But he dismisses this objection as 'utterly implausible', since we can buy fertilized eggs in grocery stores.[9]

This is either equivocation or a reflection of the fact that we use the word 'egg' very inconsistently in general. Indeed, we can decisively show that we do not use the word 'egg' in the same way when discussing humans as we do when discussing chickens. It is highly doubtful that we would call anything in human embryology an 'egg' other than an egg cell or (if Mills is right) a zygote. But in chicken embryology, an enormous number of different structures can be called an 'egg', many of which would not be called an 'egg' in the case of humans. For example, a chicken oocyte can be an 'egg'. But so can a highly developed chicken embryo complete with yolk sac, vitelline membrane, shell and so on. It can even be the composite of an eggshell along with a variety of its contents *minus* the chick. Eggs can also be hard-boiled or scrambled and remain 'eggs', despite the implausibility of hard-boiled or scrambled eggs being identical with the original egg cells.

At other times, 'egg' is used as a mass noun. Thus, when the egg is completely destroyed and dissolved, we still say that cake or cake dough contains 'egg', or that people are allergic to 'egg' just in case they are allergic to a particular protein found mainly in chickens' eggs. If Mills thinks that our use of 'egg' tracks the survival of eggy substances, he will be committed to many absurd claims, including the claim that eggs survive even when dissolved in cakes. He might not find this absurd; but in that case, he should not find absurd the idea that sperm cells still have a claim to surviving their dissolution in an egg cell during fertilization. Since he later claims that sperm cells obviously do not survive their dissolution, we take it that Mills will not want to pursue this option.

The point here is that 'egg' clearly has multiple senses and is quite ambiguous. A substantial metaphysical conclusion such as EZ-identity cannot simply be based on the fact that we sometimes use 'egg' to refer to a fertilized zygote.

If one is to make arguments on the basis of the usage of words, one recognized dictionary definition of 'egg' is 'female gamete'.[10] This usage is much more relevant to human biology than avian eggs. But gametes are haploid, and since zygotes are not haploid, they are not eggs in this sense.

Mills could respond by noting that even if we were to show that the zygote is not an egg, it would not follow that EZ-identity is false.

[5]Mills, *op. cit*. note 1, pp. 323–348.

[6]Mills often prefers 'conception', but we have standardized this article by using the more precise 'fertilization'.

[7]Or were relevantly associated with them; henceforth we will assume that any strictly animalist claims can be translated into similar views according to which we began to exist when our organism began to exist, e.g. some versions of the constitution view. So our argument will not be relevant only to strict animalists.

[8]Mills, *op. cit*. note 1, p. 327.

[9]Mills is technically correct here, though it is extremely unusual to buy fertilized hens' eggs – most 'eggs' in shops are unfertilized.

[10]E.g. 'egg'. Dictionary.com. *The American Heritage Science Dictionary*. Houghton Mifflin Company. Retrieved from: http://www.dictionary.com/browse/egg

For it could be that 'egg' is a phase sortal and that the thing which happens to be an egg survives fertilization even though it ceases to be an egg. But in this case, the terminological argument has been abandoned, and he must find other reasons for holding to EZ-identity. Our remarks decisively undermine any argument relying on the way we talk about chickens' eggs. And Mills will have a harder time arguing that *something* survives after fertilization if it is not an egg, for reasons we will explain in section 2.3.

2.2 | The microscope argument

Mills then argues that if you 'review some sex education materials' and watch an oocyte under a microscope, you will see that it still exists after fertilization. The claim here is ambiguous between the claim that the egg still exists qua egg, and the claim that the thing which was an egg still exists. Under the first interpretation, it should be quite clear that just 'watching it' will not suffice, since we know that the essential criteria for many biological kinds (e.g. being haploid) can begin or end on a scale invisible to light microscopes. Looking at an egg being fertilized under an ordinary light microscope is similar to looking through a telescope at a person dying in her sleep far away – in both cases, the relevant change is not visible.

One might insist that we see the continued existence of the chunk of matter, but that the egg is not identical with its chunk of matter (at most being constituted by it). Alternatively, one might insist that we see the continued existence of the 'thing'. These constitute the second interpretation – that the 'thing' that was an egg still exists. But in this case, the inference from 'looks roughly the same as' to 'is identical with' is still highly suspect, given that there are changes invisible to simple light microscopes which plausibly constitute changes in identity. We already know that an egg ceases to exist qua egg at fertilization despite no clear visible changes. It is not, therefore, obvious just from the lack of clear visible changes that the *thing* continues to exist. We discuss further the plausibility of Mills' 'same *thing*' gambit in section 2.3.

Mills talks here and elsewhere as though the only way something could begin or cease to exist is for its coarse material constituents to immediately congregate or dissipate. We should not grant this. Typical cases of the death of an organism do not involve the dissipation of coarse material constituents, for example.

Moreover, we can think of some cases where there is – to the naked eye and to light microscopes – general material similarity, and yet a complete change in identity. If you suppose that, *in an instant*, the wood constituting Theseus' ship is reassembled elsewhere and replaced by imitation-wood plastic boards in the original space, we have good reason to suppose that the remodelled ship is not identical to the original ship, despite it looking superficially similar. As we suggest later, there is good reason to suppose that becoming diploid is more analogous to replacement than it is to adult-onset Down Syndrome, to which Mills likens fertilization.

Moreover, it is likely that in most (or at least many) cases where something begins to exist, there will be some prior thing or composite object which looks, to the naked eye, fairly similar and which nevertheless ceases to exist when the novel thing begins to exist. So macroscopic material similarity is not always good evidence of identity.

For these reasons, it is implausible that any persuasive argument for EZ-identity can be mustered from the fact that, to the naked eye and a standard light microscope, there are no macro-level structural changes to the zygote.

2.3 | Kinds of identity and the 'same thing' gambit

How easy would it be for Mills to justify the claim that 'the thing' continues to exist as a zygote? In both of his arguments, Mills insists that all that matters is that the *thing* continues to exist, even if not as an oocyte. This is dubious, but requires a brief exploration of relative identity.

Either identity is relative or not. Suppose it is. Relative identity theorists deny that it makes sense to say that *x* is 'the same thing' as *y*. It only makes sense to say that *x* is the same *F* as *y* when *F* is a sufficiently specific sortal, like 'organism' or 'person' or 'work of art'. On relative identity theory, then, it makes no sense to say that the egg is the same thing as the zygote, unless the context identifies a relevant sortal.

An obviously relevant sortal is 'organism'. But, for reasons we give in the rest of the article, it is implausible that the egg is the same organism as the zygote. Moreover, Mills' arguments so far considered are not appropriate to the identity under this sortal. The microscope argument is not sensitive to the kind of fine organic detail that distinguishes an organism from a dead chunk of matter, and as we saw 'egg' is used for things that aren't organisms, like hardboiled eggs.

One might try exploring another sortal under which the unfertilized egg and zygote may be identical: 'cell'. Perhaps the unfertilized egg is the same *cell* as the resulting zygote. This is not completely obvious: it is not clear that cells survive becoming diploid, for example. But notice that this sortal is not one under which *anyone* would say that we are the same as the zygote – I am not the same cell as the zygote, because I am not a cell at all (and for that matter, neither is the zygote, except perhaps for the first hours after fertilization) – and hence cannot be the sortal relevant to the debate. Mills wants to argue that, for some sortal *F*, if one is the same *F* as the zygote, then one is the same *F* as the ovum, and wants his thesis to have some real bite. But for it to have real bite, the antecedent has to be one that someone in the debate might accept, and no one in the debate will say that we are the same cell as the zygote. We want to know if there is a sortal F such that we are the same F as both the zygote and the ovum. For these purposes, 'cell' will not suffice.[11]

Nonetheless, there is a sortal *F* such that a relative identity theorist could without much controversy say that the egg is the same *F* as the zygote: 'coarse-grained chunk of matter'. Unlike fine-grained chunks of

[11]We also point the reader forward to our arguments against EZ-identity. For the most part, these arguments have equal force against the view that the egg and the zygote are the same cell. But we also note there that our view is consistent with human organisms beginning to exist at the very end of fertilization – when the zygote becomes a two-celled organism. In this case, *even if Mills is right* that the oocyte and the zygote are the same cell, this is no reason to doubt our thesis.

matter which perish as soon as a single particle detaches from the chunk, coarse-grained chunks of matter can survive the addition or subtraction of a small amount of matter. If we boil an egg, we maintain the same coarse-grained chunk of matter, even though some of the shell molecules will have passed into the water. Mills' arguments work quite well if that is the relevant sortal.

However, the conclusion that the egg is the same coarse-grained chunk of matter as the organism, even if plausible,[12] just does not have any interesting implications for beginning-of-life ethics, just as the conclusion that the corpse is the same coarse-grained chunk of matter as the organism doesn't tell us much regarding physician-assisted suicide. The sortal in question is just not ethically interesting.

Mills' focus on sameness of sortal seems to suggest that two temporospatially adjacent objects falling under the same sortal is enough to guarantee their identity. But this is not the case. Even if the zygote were an egg, it would not *logically follow* that it is the same egg as the ovum prior to it. After all, if one adds an atom of oxygen to an H_2 molecule, one begins and ends with a molecule. But it is implausible to suppose that the resulting water molecule is the *same* molecule as the original H_2 molecule, and the fact that we call both things a 'molecule' seems to do very little work in securing their identity.

But – turning to the present suggestion – even less work in securing identity is done once we move to less specific sortals – especially if the sortal in question is just 'thing'. If we begin with a carbon atom at t_1 and make small, gradual changes until we end up with a chair, it is hugely implausible that we have the same 'thing' – and the fact that we call both 'a thing' is no evidence that they are identical.

This consideration cuts to some extent against Mills' first two arguments. But it also suggests the following rough test for whether *x* at t_1 and *y* at t_2 are identical: how specific is the kind under which both fall? If there is a highly specific kind, then we have some hope for identity – though no guarantee (if you have an H_2 molecule, and you swap out one of the hydrogen atoms for an atom from another molecule, you still have an H_2 molecule, but probably a different one). On the other hand, the absence of a highly specific kind that both objects fall under is strong evidence against identity. Indeed, those who hold to relative identity tend to avoid generic sortals like 'thing' altogether, and for good reason. So it is difficult to see how appealing to relative identity could help Mills here.

In the case of the egg and the zygote, *thing* is obviously far too unspecific a kind to give us any presumption of identity. *Organism* is quite specific, but the unfertilized egg is no more an organism than any of our of our other cells – at least, Mills has done nothing to argue that it is. And *cell* is irrelevant to the debate entirely.

In short, if identity is relative, it is not enough to show that eggs and zygotes are identical under *some* sortal – that is trivially easy. Rather, Mills must show that eggs and zygotes are identical under a morally relevant sortal *F*, and *F* must be one such that there is a serious option of holding that I and the zygote are the same *F*.

If identity is relative, then establishing it under a sortal is not exceptionally difficult. But suppose that identity is not relative. Then one cannot make identity claims as easily as Mills does. For many sortals will only be phase sortals which are irrelevant to identity, and some sortals will not be substantive at all. Establishing identity is no longer a mere case of finding some vaguely substantive sortal under which *x* at t_1 and *y* at t_2 fall: *x* and *y* are either identical absolutely or not identical at all. And it is very plausible that only a limited number of highly specific sortals are substantive enough for identity. At the very least, it strains credulity to think that 'thing' is substantive enough to serve as a sortal for generating identity. It would be extremely difficult, for example, to know which 'thing' survives when two hydrogen atoms bond to form a hydrogen molecule, or to know whether proper parts of 'things' have their own identity as 'things', and so on. In any case, it is highly probable that the more specific sortals – like 'person' and 'organism' – are the basis of the persistence of those things. The same test applies: if the most specific sortal we can predicate of two objects together is 'thing', then making claims of identity will be a hard sell.

For all these reasons, it is very implausible to suppose that – while forgoing the idea that eggs and zygotes share *any* reasonably specific or substantive sortal in common – eggs and zygotes are nevertheless identical solely in virtue of both being temporospatially adjacent '*things*'. Mills must provide other arguments for EZ-identity and, as we have seen, the others he does provide fail to generate his desired conclusion.

3 | REASONS TO REJECT EZ-IDENTITY

Mills gave two direct arguments for EZ-identity: the terminological argument and the microscope argument. So far we have concluded that neither of these offer much reason to suppose that eggs and zygotes are identical, and especially not under a relevant sortal.

The rejection of EZ-identity is, for many people, the commonsense view. It is intuitively clear to many, perhaps most, people that fertilization marks the start of a new human organism. We suggest that we are justified in relying on this intuition in the absence of any compelling reason to the contrary. Since the arguments Mills gives to the contrary are unpersuasive, it follows that those with the relevant intuition may reasonably trust it.

As it happens, there are good supplementary reasons to suppose that EZ-identity is false. Some of these are partially anticipated by Mills, while others are not. We begin with those Mills anticipates.

3.1 | Genetic essentialism and genetic evidence

One set of such reasons relates to certain theses concerning necessary conditions of identity. Mills considers genetic essentialism, understood as the thesis that one's original genetic endowment is essential to one's existence, and the necessity of origin, understood as the thesis that one's original cause is essential to one's existence. He argues that applying these to the current case only yields the view that we began

[12]It is doubtful that it remains the same coarse-grained chunk of matter for long, at the very least. It is difficult to believe that the same coarse-grained chunk of matter persists from an ovum until the blastocyst, let alone into adulthood. For one thing, the oocyte loses a large chunk of its matter in the beginning stages of fertilization, as we explain later.

to exist at fertilization if we already assume that we began to exist at fertilization. After all, these two theses are compatible with our beginning to exist as a blastocyst (or, we add, as a 20-year-old).

We agree, of course. But there are grounds for denying EZ-identity in the vicinity of these essentialist theses. We turn first to genetic essentialism.

Mills points out that genetic essentialism is compatible with our beginning to exist as egg cells, since genetic essentialism pertains only to original genetic endowment, allowing for changes in genetic composition at a later stage. This is, of course, correct as far as it goes. But the fact that *some* diachronic differences in genetic endowment are possible within a single organism does not show that any kind and magnitude of genetic change is possible.

Mills, for instance, argues that we might survive adult-onset Down Syndrome, which would involve the sudden addition of an extra chromosome 21 to our genome in each cell of our body. So, Mills asks, why can other genetic changes not preserve identity?

It is, however, far from obvious that the organism with adult-onset Down Syndrome would be identical with the previous organism. But even if we grant Mills this case, there are clear differences between adult-onset Down Syndrome and fertilization which suggest that Mills' approach is misguided.

First, it is widely granted that material objects survive small, gradual changes in material constitution, but most people accept that there is an enormous difference between these changes and very large, sudden ones. Theseus' ship can survive one of its sculptures turning to aluminium, but it probably does not survive a sudden, complete remodelling into aluminium (especially not if the original wood is reassembled elsewhere). This is the case despite the macro-level structure remaining the same. Similarly, it is far from obvious that an organism's immediately becoming diploid from haploid allows the organism to survive.

Let us modify Mills' example of adult-onset Down Syndrome to make it more analogous. Mills thinks that it is obvious that his organism would survive adult-onset Down Syndrome. Let us grant this for the sake of argument. But what would happen if Mills' organism had adult-onset haploidy? It is far from obvious that it would survive this. The organism – if there even were a unified organism – would function completely differently, and it would die very quickly.

Or consider the following: it is counterintuitive to think that an elephant could survive a gradual cell-by-cell change into a banana plant. But what plausibility there might be in such a hypothesis comes from the gradual cell-by-cell nature of this change. If someone took an elephant zygote and changed its DNA into banana DNA, it is quite implausible that the zygote would survive that change – and that, if trees and elephants are identical to their zygotes, the resulting tree would be identical to the elephant who would otherwise have existed. An enormous change in an organism's genome at this early stage of development[13] is, at the very least, some evidence that the organism may not remain identical.

A further example might be a change of biological sex. It is, again, plausible that if I had a different biological sex than my actual biological sex, I would not have been the same person. If I had XX chromosomes instead of XY chromosomes, that would be some evidence that I would not be identical with who I actually turned out to be. But then, again, we have some evidence that moderate-to-large scale genetic changes are some evidence against organismic identity.

These points motivate what we call moderate genetic essentialism, the thesis that we couldn't have been *significantly* genetically different at fertilization. But given this thesis we can argue against Mills in two different ways.

First, we have the obvious argument that if the zygote is identical with the fertilized egg, then because that egg could have been fertilized by a different sperm, the resultant zygote's (and hence, in our view, the resultant adult's) genetic endowment could have been significantly genetically different at fertilization. But this runs contrary to moderate genetic essentialism. But since moderate genetic essentialism is plausibly true, this gives some reason to reject EZ-identity.

Mills could respond by saying that swapping out the genes contributed by one human sperm for the genes contributed by another human sperm does not count as a sufficiently great difference to preclude identity. After all, most of the DNA in two different *human* sperm is the same.

It is worth noting the limited force of this response. In the first place, we recommend a re-calibration of what constitutes a significant genetic change. While DNA between sperm cells is very similar, the same is true when comparing human DNA with chimpanzee DNA. Even bananas are said to have 50% genetic similarity with humans. There are complicated questions about how to measure genetic similarity, which are beyond the scope of this article. But it can easily be seen both from cross-species comparisons and from theoretical genetics that very small changes in DNA can have *enormous* effects on the resultant organism – and that a genetic change which is small judging by the proportion of base-pairs involved relative to the entire genome may be enormous using phenotypic measures.

For example, just changing one base out of thousands can dramatically alter the folding of the resultant polypeptide and thereby the functioning of the resultant protein. For example, the HEXA gene on chromosome 15 is about 35,000 nucleotide bases long. A single base change can be responsible for Tay-Sachs disease, which causes profound, progressive neurological disability and usually death by age 4. Telling us that the HEXA gene is over 99.99% similar between a child with Tay-Sachs and without is not very informative about overall gene and organismic function, and suggests that even miniscule changes to DNA can – in the right circumstances – drastically affect the organism, plausibly to the extent that identity is not preserved.[14] These

[13]We remain agnostic on the question of whether a genetic change is more likely to affect identity (or evidence of an identity change) in the infancy of an organism than in a mature organism. There may be some reason to think this: but we do not assume so in this article.

[14]Note that Tay-Sachs is unlikely to be the most dramatic example of a point mutation causing profound changes in function. It is very likely that some point mutations result in unviable embryos or foetuses – these are simply less studied because our medical research and knowledge is focused much more on conditions compatible with postnatal life.

considerations warrant extreme caution in supposing that any given genetic change is relatively minor. While we do not claim that adult-onset Tay-Sachs or adult-onset Down Syndrome would necessarily affect identity, we note here that we are prone to underestimating the magnitude of genetic difference if we use the wrong measure.

The greater the difference of genetic endowment, the more plausible – especially in a single-celled organism – that the organism cannot survive the change. But now the difference between being haploid and being diploid is much more significant than the difference between two human genetic endowments. It is much more significant than even the difference between incredibly different species. If species-membership is an essential feature of a given organism, or even if it is just evidentially relevant, then the even more drastic change from haploidy to diploidy should be viewed similarly.

How do these points aid our view? Either the egg does or does not survive becoming diploid. If it does not survive, then Mills' argument fails. But if it does survive, then *a fortiori* the unfertilized egg should survive *very significant* genetic change, since becoming diploid is an extreme amount of genetic change. Let Egg be the unfertilized egg that actually developed into Mills. Suppose that in another possible world Egg was subjected to significant genetic change (say, due to exposure to radiation), thereby becoming Egg*, and then Egg* was fertilized and eventually became the human individual Mills*. Then Egg is identical with Egg*, since (on our assumption that eggs survive becoming diploid) eggs survive very significant genetic change. And if Egg is identical with Mills, then by the same token Egg* is identical with Mills*. By symmetry, transitivity and necessity of identity, it follows that Mills is identical with Mills*. But Mills and Mills* were significantly genetically different at fertilization, so on the basis of moderate genetic essentialism, they are not identical, and hence the kind of genetic change in becoming diploid cannot be survived.

Whether or not we accept moderate genetic essentialism in its exact form described here, it seems plausible that the magnitude and kind of the genetic change, as well as, perhaps, the point at which it occurs, bear on the identity of the organism. At the very least, these changes are good *evidence* of differing identity, even if they are not conclusive or constitutive of it. And the magnitude of the change from haploidy to diploidy is much greater than Mills supposes.

Let us round this section off by exploiting these considerations in some more thought experiments.

According to Mills, the egg survives becoming diploid. Actually, as we will see, it is more complex. The secondary oocyte has 23 chromosomes, with 2 asymmetrical chromatids per chromosome. It produces a gamete with 23 chromosomes (consisting of 1 chromatid each) on contact with the spermatid. Together, they form a zygote with 46 chromosomes. Suppose that we have a single entity throughout this process. Let us now imagine a new stage for the process. The diploid one-cell zygote, which is after all a totipotent human cell, is then turned into a new oocyte. That change is no greater than the diploid-to-haploid-to-diploid change that the egg can allegedly survive, so by the same token it should be possible for it to survive the new change. But now this secondary oocyte can be united with a second spermatid, producing a new zygote. This process could in principle be run for several generations, resulting in a new secondary oocyte bearing virtually no resemblance at all to the first.

The above story is best interpreted as a story about sexual reproduction where the mother (the zygote that is going to be turned into an oocyte) does not survive. The oocyte unites with a spermatid to produce a zygote which sexually reproduces with a spermatid to produce an offspring.

But if we have EZ-Identity as Mills wants it, then in the whole story above we have a single entity (except for the spermatids) alternating between oocyte and zygote stages. It is a case where a single human organism is fertilized repeatedly, and continually receives new genetic material. But this just doesn't seem to be the right way to think of the story. After enough generations there may be no genetic material from the original left, and this fits much better with the idea that when the oocyte loses half of its DNA to become an ootid, it dies.

These cases gain even more weight when different species are introduced. Suppose that the same haploid human oocyte is fertilized in one possible world by a chimpanzee sperm cell, and in another possible world by a human sperm cell. It is surely very plausible that the resulting zygotes would not be identical. But in that case, it is equally plausible that the oocyte does not survive fertilization by the chimpanzee sperm cell. Yet this is not a much more dramatic change than becoming diploid by human fertilization. If anything, as we have seen, chimpanzee-human hybrids will be much more genetically similar to human zygotes than haploid oocytes are! It is implausible, therefore, that an oocyte would fail to survive chimpanzee fertilization but succeed in surviving human fertilization. So this is another reason to think that oocytes do not survive human fertilization.

This argument can be extended once more. Suppose not only that a zygote is turned into a secondary oocyte which is fertilized with chimpanzee DNA, but that the oocyte's human DNA is removed shortly after fertilization and replaced with female chimpanzee DNA. Again, this is a less major genetic change than that between haploidy and diploidy and so it is difficult for a proponent of EZ-identity to reject this possibility. We think it is clear that the resulting zygote would not be identical with the original egg, and so this counts against EZ-identity. But if even that is not plausible, then suppose the non-genetic changes in the zygote required for viability were made, and the cell grew into an adult chimpanzee. If nothing else, it is obvious that *this* is not identical with the original human oocyte. And yet again the genetic changes here are smaller than those between haploidy and diploidy.

So there is good reason, in sum, to suppose that the kind of genetic change involved in fertilization constitutes evidence that the egg and zygote are distinct. It may even be that the genetic changes are partly *constitutive* of this distinction. We do not rely on that claim here, and we are sceptical that it is possible to give a comprehensive theory of what constitutes organismic identity. But we are confident that the thought experiments given here suffice to warrant thinking that the enormous genetic change involved in fertilization cannot be survived by the egg.

3.2 | Necessity of origin

Genetic essentialism is not the only relevant thesis here. A variant on the necessity of origin tells us that if we had different biological parents, we

would not be the same organism. 'Biological parent' does not seem like a very contrived category, and pertains both to zygotes and adult human beings. The idea of a biological parent is woven into the concept of sexual reproduction in all sexually reproducing species. Thus, the zygote resulting from a given instance of sexual reproduction in a given species is the offspring of both the male and female animal, while the egg is clearly not the offspring of the same parents. The concept of biological offspring and parentage is widespread among sexually reproducing organisms: thus, fish and otters are the offspring of two older organisms each, and an otter zygote will be the offspring of different biological parents than the otter egg.

Moreover, biological parentage plays an enormous part both in determining the genetic make-up of an individual and – in many species – the environment of the individual. It is also operative in our moral discourse: we typically think that biological fathers have unique obligations to their offspring, for example. The notion of biological parentage is germane from the zygote stage right through to adult life, at least in many organisms. But this is a good reason to suppose that neither I nor the zygote whence I came are identical to the oocyte whence I came. For an oocyte can, in different possible worlds, be fertilized by different spermatids from different fathers. If the resulting zygotes and children are different, then by transitivity and symmetry of identity, they cannot be identical with the oocyte.

So, contra Mills, there are plausible essentialist theses which give positive reasons to reject EZ-identity. Even if these essentialist theses are false, it is still very plausible that the zygote and egg's having different parents and a profoundly different genetic makeup are at least good evidence that they are distinct, even if these differences do not constitute that distinction.

3.3 | Symmetry and fission

Mills then turns to the suggestion that the symmetry of sperm and eggs provides a reason to reject EZ-identity. The reasoning here is that the sperm and the egg both have a roughly equal claim to be identical with the zygote. But since they cannot both be identical with the zygote, the most reasonable conclusion is that neither of them is.

Mills disputes this by claiming that the egg has a greater claim to being identical with the zygote than the sperm. The sperm, he claims, is extinguished, being dissolved in the surviving egg.[15]

The argument here is wrong on a number of accounts. Firstly, it is far from clear that the egg contributes substantially more in senses relevant to identity. Mills concedes that both are necessary for the zygote, and that they contribute roughly equally genetically, but says that they are not equal in surviving fertilization.

We suggest that this assertion is not as clearly true as Mills would hope. Mills does not explain in much detail the ways in which the egg has a greater claim to survival than the sperm. As far as we can discern, the main differences are size and the integrity of the contours of the object. While these might have some weight, it is far from clear that they have as much weight in determining or indicating identity as Mills thinks. It is plausible that functional considerations are much more important than these. And the functional and behavioural roles of the genetic contribution seem, on the face of it, to be incredibly weighty. Consider as an analogy a head transplant case. Most people think that if a head is transplanted to another body, the person survives with the head rather than in the headless body. This is so despite the fact that the recipient body is much bigger than the 'donor' head. Function is more important than bulk.

But in any case, Mills is simply wrong about the biological facts. Let us recount the cellular biology of human sexual reproduction.

Human gametes are formed by meiosis, a specialized kind of cell division beginning with one cell and ending with four. Cells normally have 46 chromosomes with one chromatid each. In the first stage of meiosis, meiosis I, chromosomes join up in their 23 homologous pairs – one maternal chromosome and one paternal chromosome. Then, the chromatid composing each chromosome replicates so that each chromosome has 2 chromatids, forming the familiar 'X' shape. Genes within each homologous pair then 'recombine', so that each of the four chromatids in each homologous pair are substantially different, and unlike any chromatids in the rest of the body's cells. Then one chromosome from each pair is pulled to one end of the cell, and the other chromosome in each pair is pulled to the other end. As the cell then splits, the result is two cells with 23 chromosomes each, and with each chromosome having two chromatids (still twice the normal number). One of

[15]At this point, Mills offers a possible explanation for why so many people think that fertilization marks the beginning of a new human being. In the course of this, he notes that biologists do not have this belief 'when wearing their biologist-hats.' He then informs us that we will 'look in vain in the embryology literature for any hint that conception is anything other than an important event punctuating – not originating – the life of a single being' (Mills, *op cit*. note 1, p. 333). If Mills sincerely believes this, then he must have not looked at much embryological literature. As a doctor trained by cell biologists, embryologists, obstetricians, and other relevant kinds of biologists, it has never been difficult for me (Miller) to find other biologists who agree that the common-sense biological view of organisms is that they originate at fertilization. Nor is it difficult to find sources within biological literature confirming this view. For example: 'Human development begins at fertilization when a sperm fuses with an oocyte to form a single cell, a zygote. This highly specialized, totipotent cell marks the beginning of each of us as a unique individual.' Moore, K. L., Persaud, R. V. N., & Torchie, M. G. (2013). *The developing human: Clinically oriented embryology* (9th ed.). Philadelphia, PA: Elsevier, 13; 'Although life is a continuous process, fertilization is a critical landmark because, under ordinary circumstances, a new, genetically distinct human organism is thereby formed.' O'Rahilly, R., & Muller, F. (2001). *Human embryology and teratology* (3rd ed.). New York, NY: Wiley-Liss, 8; 'The oviduct or Fallopian tube is the anatomical region where every new life begins in mammalian species. After a long journey, the spermatozoa meet the oocyte in the specific site of the oviduct named ampulla and fertilization takes place.' Coy, P., García-Vázquez, F. A., Visconti, P. E., Avilés, M. (2012). Roles of the oviduct in mammalian fertilization. *Reproduction, 144, 649*. Further examples are not difficult to find in 20th or 21st century literature. Nor are they hard to find among respected pro-choice philosophers. For example, Peter Singer: 'In this sense there is no doubt that from the first moments of its existence an embryo conceived from human sperm and eggs is a human being.' Singer, P. (2008). *Practical ethics* (2nd Ed.). Cambridge: Cambridge University Press, 86. It is just as plausible – if not more so – that recent omissions of this claim are due to the recent ideological unpopularity of the pro-life movement rather than any developments in biology showing that this is no longer a tenable view, biologically. In any case, Mills' claim here is simply false.

these cells is discarded as a polar body, and the other becomes a secondary oocyte (or a secondary spermatocyte in the male case, which henceforth goes slightly differently; we restrict subsequent discussion to the female case). The secondary oocyte then undergoes the first part of the second cell division, meiosis II, so that the cell is ready to divide, but so that the genetic material has still not divided yet. This phase arrests until fertilization – so for most oocytes, the process is never completed.[16] A female gamete with 23 chromosomes and one chromatid per chromosome – which is called a an ootid (corresponding to the spermatid in the male case, which is typically formed significantly before copulation) – is not formed until fertilization.

During fertilization, the spermatid meets the secondary oocyte. When the spermatid's membrane fuses with the secondary oocyte, meiosis II completes and the oocyte cleaves. But at the time of cleavage, the spermatid is in between fusing with the oocyte's membrane and having its pronucleus move towards the oocyte's pronucleus. After cleavage, the pronuclei of the ootid and the spermatid move towards the centre of the cell while replicating their DNA. As the two pronuclei move towards the centre of the cell, their DNA replicates and divides, and the newly formed zygote undergoes its first round of mitosis to form a two-celled embryo.

One implication here is that there is far more symmetry between spermatid and ootid than Mills maintains. Mills is comparing the spermatid and secondary oocyte, arguing that the secondary oocyte has more of a claim to be identical with the resulting zygote. But this comparison is skewed, since we already knew that secondary oocytes and spermatids are completely different kinds of things. Only the spermatid is a gamete – the cell kind required for sexual reproduction. The oocyte has double the genetic information of the spermatid, for example. But when comparing each biological parent's contribution to the actual offspring, the ootid and the spermatid, we find that there is actually no such thing as the ootid (female gamete) until the spermatid has already entered the secondary oocyte. It cannot simply be said here that the already existing ootid is penetrated by the spermatid, which dissolves in it. The ootid only begins to exist after the spermatid has reached the secondary oocyte, and at this point it has no more claim over the zygote than the spermatid. Both have non-dissolved, demarcated pronuclei in a sea of cytoplasm and organelles, and both will replicate their DNA before meeting somewhere in the cell to form a more distinct nucleus. Since the female counterpart of the male gamete only forms at fertilization itself, and since it does not exist prior to the sperm penetrating the cell membrane, there is more symmetry here than Mills supposes. This supports the egg-sperm symmetry argument against EZ-identity.

But there is another implication against EZ-identity here. Given the biological facts, we now have a clear reason to suppose that the oocyte ceases to exist entirely. Mills already thinks that cell cleavage can sometimes be good reason to suppose that the original cell ceases to exist. At fertilization, the secondary oocyte's genetic material divides into two and separates, with the whole cell cleaving in two. One half separates and is destroyed, and the other half has its pronucleus meeting a spermatid's pronucleus to form a diploid zygote. Mills presumably thinks that in meiosis I the original oocyte ceases to exist, given its cleavage. So it should be perfectly plausible that the same is true in meiosis II. In the case of a zygote, on the other hand, we can say that the first mitosis preserves identity because of the genetic continuity, physical contiguity, organismic/physiological similarity, and so on. In the case of meiosis II of the secondary oocyte, the genetic continuity is broken, the two cells separate physically, and the two cells behave utterly differently: one is a polar body which goes on to be naturally destroyed, while the other is, or is forming, a zygote. Thus, there is good reason to suppose that the secondary oocyte is destroyed entirely at the first point of fertilization, contra Mills' suggestion that the oocyte stays roughly as it is, with the small addition of dissolved spermatid.

Here we can map some slightly different views regarding when organisms begin to exist. Mills provides three options: in the early stages of oogenesis, or sometime after fertilization, or at fertilization. We can disambiguate the last and give at least four possibilities compatible with our view: that the new organism begins to exist (a) at the time of membrane fusion between spermatid and secondary oocyte, (b) at the time of cell cleavage in meiosis II, (c) when the genetic material from spermatid and ootid are united or (d) at the time of the first mitosis of the zygote.[17] We do not make any claim about which of these is true: only that it is most plausible that the disjunction of these views is true. It is helpful, at least, to map out the terrain of possibilities here for clarity's sake. And in none of the four cases is the secondary oocyte – the still-diploid 'egg' prior to the contact with the spermatid that makes it haploid – identical with the zygote.

3.4. | Ethical intuition

One further reason for thinking that eggs and zygotes are relevantly dissimilar is moral intuition: it is just *obvious* to most people that eggs are not significantly morally valuable. But to many people, it is far from obvious that zygotes or early embryos are not significantly morally valuable. There is an ethical intuition that the cases are morally different, even if the exact importance of the difference is controversial. This is itself a reason for people with such an intuition to think that EZ-identity is false. Mills here confuses lack of universally compelling argument with lack of reason. While it is true that those not sharing the original intuitions cannot be argued into rejecting EZ-identity by this route, having these intuitions is at least some reason to reject EZ-

[16]Cooper, G. M. (2000). *The cell: A molecular approach* (2nd ed.). Sunderland, MA: Sinauer Associates.

[17]If Mills is right that fission is a good reason for holding that two substances are distinct, then (d) may be one of the more plausible options. If (a)-(c) are false, then (d) looks like one of the more likely candidates – Mills does not explain in the paper why he thinks that the two resultant blastomeres do not compose an organism, only gesturing in the direction of 'the further details of embryology'. According to some accounts of fertilization, fertilization only ends at the first mitotic division. If so, (a)-(d) are all compatible with the thesis that organisms begin to exist at fertilization. So there is good reason to suppose that at least one of them is true – and if so, then there is good reason to suppose that organisms begin to exist at fertilization.

identity. And for those with the relevant intuitions, there is a good inductive argument against EZ-identity here, even if not a conclusive one.[18]

3.5 | Head transplants

One final reason for rejecting EZ-identity is by appeal to an analogy to which we alluded earlier. We said earlier that functional considerations are often much more important to identity than considerations of size. So, for example, most people hold that in head transplants, the person goes with the head rather than with the rest of the body. But as well as diminishing the force of Mills' microscope argument for EZ-identity, this analogy also provides positive reason to reject EZ-identity. For if we suppose that the nuclei of cells are relevantly similar to heads (or brains, or cerebrums) then, by analogy, since there is considerable reason to suppose that we would not survive losing half of our head or brain and gaining a new half from someone else, there is also considerable reason to suppose that a cell does not survive the loss and gain of half a nucleus, as happens during fertilization.

Cell nuclei are indeed frequently understood as being the control centre of the cell – sometimes even as the 'brain' of the cell. It is not difficult to see why: the nucleus is responsible for regulating the transcription and translation of genes, thereby determining in large part the behaviour and type of cell. The selection of transcribed and translated genes – collectively known as the *expression* of genes – determines, for example, whether the cell becomes a neuron, or a muscle cell, or a skin cell, just as the brain of an organism determines the behaviour of that organism. The rest of the cell – mitochondria, cytoplasm, Golgi apparatus, and so on – is given more mundane (though complex) tasks, just as in the rest of the body. This analogy has considerable plausibility – and so we have further reason to resist Mills' arguments for EZ-identity, as well as further positive reason to reject EZ-identity.

4 | CONCLUSIONS

One of the main arguments against the traditional view that organisms begin to exist at fertilization is that egg cells and zygotes are identical. Mills gives two arguments for this view. Mills' argument from fertilized chicken eggs trades on an obvious multiplicity of sense of 'egg'. His argument from coarse structure misses the functional issues central to organisms and the importance of invisible changes in general.

Contra Mills, there are many good reasons to think that eggs and zygotes are not identical. Some of these may be individually decisive, while others may only count as contributory evidence. Either way, it is clear that there is at least some reason to think that EZ-identity is false. These reasons are as follows: the plausibility of moderate genetic essentialism, the implausibility of a cell surviving repeated haploidy and diploidy (especially cross-species), the plausibility of parental essentialism, the evidential value of genetic differences, the symmetry of sperm and egg, the multiple cases of fission in fertilization, the difference in ethical intuitions between eggs and zygotes, and the plausibility of head transplant analogies.

The best reading of the metaphysics of fertilization is that the oocyte and spermatid come together to produce a new organism, the zygote. It is very plausible, in our view, that the zygote is identical to the mature human organism that it grows into. But it is clear that whether or not you are identical with that organism, and hence with the zygote, neither you nor that organism is identical with the secondary oocyte that precedes it.

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[18]We appreciate that this argument depends on the thesis that identity preserves moral value – so that if the egg and zygote are identical, then they must both be valuable or neither valuable. We do not have space to defend this assumption in this article, but briefly note the argument here for completeness' sake. The argument may be taken up elsewhere, and we do not depend on it in this article.