Examining When Life Begins by Explaining Fission and Fusion in the Human Organism

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Abstract. The question of when human life begins is critical in debates related to life issues. While there are a variety of proposals as to how an organism should be defined, many biologists and ethicists, particularly Catholics, have approached this issue by arguing that fertilization defines the beginning of a new organism. Examining the processes of fission and fusion, which take place before gastrulation, provides strong evidence for when human life beings and therefore how it should be defined. Among the four dominant theories, regulative fission and fusion are the best explanations in terms of being the most consistent with the biological data. This explanation of twinning provides compelling evidence that fertilization is not a necessary condition for human generation, although it may be a sufficient condition. While fertilization generates the vast majority of human beings, additional human beings may rarely be generated during fission events. *National Catholic Bioethics Quarterly* 21.4 (Winter 2021): 619–632.

The question of when a human life begins is critical in debates related to life issues such as abortion, embryo-destructive stem cell research, and embryonic gene editing. In a study that asked 2,899 participants, "How important is the question 'When does a human's life begin?' in the US Abortion Debate?" 87 percent rated this as an important issue. Eighty-four percent of these same participants agreed that "Americans deserve to know when a human's life begins so they can be informed

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in their abortion positions and reproductive decisions."[1] While there are a variety of proposals as to how an organism should be defined,[2] many biologists and ethicists, particularly Catholics, have approached this issue by arguing that fertilization defines the beginning of a new organism.[3]

Examining the processes of fission and fusion, which take place during twinning, helps us to discern when human life begins and how it should be defined. Available biological data best support specific explanations of fission and fusion and are consistent with only certain accounts of when life beings. Of the four theories of fission and fusion—nonhuman, deadly, conjoined, and regulative—the regulative theory is currently the best explanation of these processes. This theory implies that fertilization is not a necessary condition for human generation, although it is still possibly a sufficient condition.

The question of whether fertilization is a necessary or a sufficient condition for the generation of a human organism is an important one because answering it can help us discern what is a human organism; further, it will tell us something about what it means for us to be human.[4] If fertilization is both a necessary and a sufficient condition for human generation, then it would be a complete explanation

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1. Stephen Jacobs, "Biologists' Consensus on 'When Life Begins,'" *SSRN Electronic Journal* (August 2018): 8, doi: 10.2139/ssrn.3211703.
2. Maureen Condic and Samuel Condic, "Defining Organisms by Organization," *National Catholic Bioethics Quarterly* 5.2 (Summer 2005): 331–353, doi: 10.5840/ncbq20055250; Keith Farnsworth et al., "Living Is Information Processing: From Molecules to Global Systems," *Acta biotheoretica* 61 (March 2, 2013): 203–222, doi: 10.1007/s10441-013-9179-3; Tibor Gánti, "Organization of Chemical Reactions into Dividing and Metabolizing Units: The Chemotons," *BioSystems* 7.1 (July 1975): 15–21, doi: 10.1016/0303-2647(75)90038-6; Bernard Korzeniewski, "Cybernetic Formulation of the Definition of Life," *Journal of Theoretical Biology* 209.3 (April 7, 2001): 275–286, doi: 10.1006/jtbi.2001.2262; Bernd Rosslenbroich, "Properties of Life: Toward a Coherent Understanding of the Organism," *Acta biotheoretica* 64 (August 2, 2016): 277–307, doi: 10.1007/s10441-016-9284-1; and Erwin Schrödinger, "What Is Life? The Physical Aspect of the Living Cell," in *What Is Life?* (New York: Cambridge University Press, 1992), 3–92.
3. Maureen Condic, "When Does Human Life Begin? A Scientific Perspective," *Westchester Institute* 1.1 (October 2008): 1–18; Keith L. Moore et al., *Before We Are Born: Essentials of Embryology and Birth Defects,* 8th ed. (Philadelphia: Elsevier, 2012), 327; Scott Gilbert, *Developmental Biology*, 10th ed. (Sunderland, MA: Sinauer Associates, 2014), 109; and Shirly J. Wright, *A Photographic Atlas of Developmental Biology,* (Englewood, CO: Morton Publishing, 2005), 53. Several other texts, rather than explicitly saying fertilization marks the beginning of a *new individual* or organism, claim that it marks the beginning of development, which implies that an entity has remained the same while changing characteristics though successive stages. In short, identifying the beginning of development tacitly identifies the beginning of the organism. See Lewis Wolpert and Cheryll Tickle, *Principles of Development*, 4th ed. (Oxford: Oxford University Press, 2011), 52; Larry Cochard, *Netters Atlas of Human Embryology,* (Philadelphia: Elsevier Saunders, 2012), 1; and Fred H. Wilt and Sarah C. Hake, *Principles of Developmental Biology* (New York: Norton, 2004), 13.
4. While it is beyond the scope of this paper to completely identify the necessary and sufficient conditions for human generation, we will attempt to narrow the possibilities.

of what it means for a human organism to begin, because it would specify all and only those things that are required for human generation. If fertilization is merely a sufficient condition for human generation, then it would be one way that a human organism could come to be, but it may not be the only way. If fertilization is merely a necessary condition for human generation, then it would have to occur in every instance of the generation of human life, but it may not be "all that it takes" for human generation to occur.

Embryo Fission

Monozygotic twinning, also known as embryo fission, occurs when an embryo splits during the first two weeks of development.[5] After two weeks, the embryo undergoes a process called gastrulation, where its cells rearrange themselves to form three basic tissue layers called germ layers. After gastrulation the embryo loses the ability to undergo twinning. Through fission, two organisms exist after a single fertilization event. The question is, At what point did these two organisms come into existence? Did this occur before or after twinning? As testified to by the vast amount of literature on this topic, many scientific and metaphysical explanations of embryo fission have been proposed.[6] There are at least four possible ways to account for this process, which we refer to as nonhuman, deadly, conjoined, or regulative fission.[7]

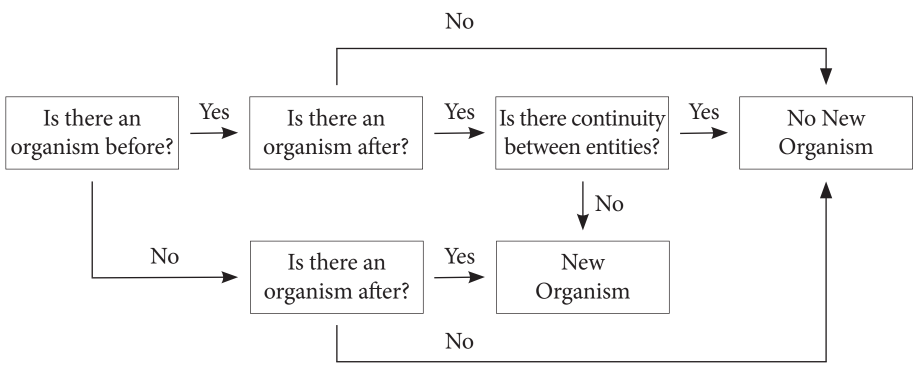
In order to better understand how different theories attempt to explain fission, it is important to have a clear definition of when human organisms are generated.

5. It is believed that twinning events in the first twelve days of development lead to separate monozygotic twins. Between thirteen and fifteen days, it is possible that the monozygotic twins will be conjoined. The argument we present is most easily applied to separate monozygotic twins. However, a similar argument could be made that also applies to conjoined twins.
6. John Haldane and Patrick Lee, "Aquinas on Human Ensoulment, Abortion and the Value of Life," *Philosophy* 78.304 (April 2003): 255–278; Jason T. Eberl, "Aquinas's Account of Human Embryogenesis and Recent Interpretations," *Journal of Medicine and Philosophy* 30.4 (2005): 379–394, doi: 10.1080/03605310591008559; David Oderberg, "The Metaphysical Status of the Embryo: Some Arguments Revisited," *Journal of Applied Philosophy* 25.4 (November 2008): 263–276, doi: 10.1111/j.1468-5930.2008.00421.x; Mathew Lu, "The Ontogenesis of the Human Person: A Neo-Aristotelian View," *University of St. Thomas Journal of Law and Public Policy* 8.1 (Fall 2013): 96–116; Maureen Condic and Kevin Flannery, "A Contemporary Aristotelian Embryology," *Nova et vetera* 12.2 (2014): 495–508; and David Alvargonzales, "The Constitution of the Human Embryo as Substantial Change," *Journal of Medicine and Philosophy* 41.2 (April 2016): 172–191, doi: 10.1093/jmp/jhv062. While all of these papers may not directly address fission and fusion in the human embryo, they are at least dealing with closely related issues.
7. Rose Koch-Hershenov, "Totipotency, Twinning, and Ensoulment at Fertilization," *Journal of Medicine and Philosophy* 31.2 (January 2006): 141–142, doi: 10.1080/03605310600588673. In addition, it is possible that fission does not immediately generate two organisms. If the organisms are generated with some delay, it would not significantly alter the strengths and weaknesses of each theory. On the other hand, a fission-like event could generate fewer than two organisms, but this would not result in twins and would therefore not count as fission in the sense that we are examining here.

We propose that the presence of a new organism can be defined with a series of rhetorical questions (figure 1).

Figure 1

Questions for Whether an Event Generates a New Organism



First, after some change has occurred, one asks if there was an organism before the change, and if there is an organism after the change occurs. If there was not an organism before but there is an organism after, then a new organism has been created. If there was not an organism before and not an organism after, then no new organism has been created. If there was an organism before and there was not an organism after, then there is not a new organism. If there was an organism before and an organism after, then a new question arises: Is there continuity between them; that is, is the organism that was present prior to the change the same one that is present after the change? If there is continuity, then there is not a new organism; but if there is not continuity, then a new organism is created.

Nonhuman Fission

According to nonhuman fission theory, the original embryo (A) is not an organism or at least not a human organism. When the embryo divides, two new, human organisms (B and C) are eventually generated. This scenario is a popular philosophical explanation of fission, and it is argued that when fission is possible, the embryo cannot be a human organism, since human organisms cannot split into two organisms.[8] Since fission is possible only before gastrulation, this theory says that the embryo could not possibly be human until after gastrulation has occurred, and the embryo before gastrulation is not the same entity as the one after gastrulation. According to this explanation, fertilization is neither a necessary nor a sufficient condition for the generation of human life. In fact, fertilization would never generate human life, because a human organism does not exist until fission is no longer possible. Thus, nonhuman fission is a challenge to the idea that human life starts at fertilization.

8. Koch-Hershenov, "Totipotency, Twinning, and Ensoulment," 157.

One issue with nonhuman fission is that embryos A, B, and C all seem to be the same kind of thing—they are all human embryos. To cite some distinction between them, while recognizing that they are all embryos, takes the position that what makes us human organisms is not always present in the embryo. In other words, it would lead to the bizarre conclusion that there can be an embryo that is an organism with human parents that is not itself a human. If it is not a human organism, then what kind of organism is it?

Further, biological evidence points to continuity of a human organism through the fission event; the time when fission is no longer possible signifies nothing more than a mere developmental change. Nonhuman fission theory says that adult humans are continuous with human embryos only after fission is no longer possible. However, even when fission does not occur but is still possible, a continuous process of development occurs before and after gastrulation. This continuous development would suggest both that the ability to undergo fission is irrelevant to the constitution of the human embryo and that continuity exists between the pre- and post-fission embryo.[9] Given the persuasive evidence for the continuity of a human organism through the fission event, nonhuman fission cannot be correct.

Deadly Fission

An alternative to nonhuman fission that attempts to save the humanity of the early embryo is what we are calling *deadly fission*. According to this theory, human organism A splits and creates human organisms B and C. In this case, A is not the same organism as B or C, and it did not survive the process of fission. In deadly fission, fertilization is not a necessary condition for the generation of human life, because the process that generates organisms B and C does not involve a fertilization event (even though B and C may require material that was created in a prior fertilization event); but fertilization could be a sufficient condition for human generation as it does generate embryo A. This scenario may be the most prominent among defenders of the humanity of the early embryo.

One criticism of deadly fission is that if it occurs when cells that can become a new organism split into two groups, then it would seem that this same thing happens when the zygote splits.[10] This would mean that every act of fertilization would result in the death of at least one human organism at the first cell division and perhaps at every cell division up to gastrulation. Further, this account raises concerns about the theological implications of God's having created a system where fertilization always kills one or more human organisms. One possible solution is to posit that the *splitting* that occurs with the physical separation of cells at fission is different from the *dividing* that occurs within cells after fertilization. While splitting would kill a human organism, dividing would not generate or kill any organisms. However, even if no human organisms die during the first few cell divisions, it would still, in our view, be uncomfortable to believe that God created a system where fission requires the death of a young human organism.

9. Bruce Carlson, *Human Embryology and Developmental Biology*, 4th ed. (Philadelphia: Mosby Elsevier, 2009), 54.
10. Koch-Hershenov, "Totipotency, Twinning, and Ensoulment," 141.

Another weakness of deadly fission is that it proposes dual origins of human generation; some human beings would begin at fertilization, and some human beings would begin at fission. Supporters of deadly fission often start with the perspective that human life begins at fertilization. In part, deadly fission is proposed to save the humanity of the early embryo from the challenge of nonhuman fission. This motivation can make the dual origins that result from deadly fission seem ad hoc. In other words, the criticism leveled is that deadly fission proponents are hand waving in an attempt to mask the deficiencies in a theory of human generation that relies solely on fertilization, proposing a new mechanism of unrelated, dual origins of human organisms based not on apparent biological evidence but merely on the (admirable) desire to save the humanity of the human embryo.

Proponents could reply that the theory and its dual origins are not ad hoc, as deadly fission is a common philosophical explanation of what happens when single-celled organisms such as amoebas divide.[11] However, if division and splitting are different, then deadly fission can still be criticized as ad hoc for the reasons given above. If division and splitting are not different, then the death that would be required from the early cell divisions cannot be avoided. Either way, deadly fission theory has a serious weakness. Another serious problem is that on this account, there is no continuity between organisms before and after fission. As noted above, the biological evidence points to continuity of a human organism before and after the fission event. A final issue with deadly fission is that while it posits the death of a human organism, the biological signs of death are absent. There is no tissue decay, cessation of development, or any other known biological sign of death of the original embryo. If development continues normally with no signs of death, the natural conclusion would be that the original embryo never died and continues to persist after fission. Given the challenges noted above, deadly fission is very unlikely to be an adequate account of embryo fission.

Conjoined Fission

Conjoined fission theory indicates that a human organism is created at fertilization and that there is continuity between organisms before and after fission. According to this theory, if fission will eventually occur, two organisms are created at fertilization (AB).[12] These organisms share one body, similar to conjoined twins. At the fission event, the conjoined twins will physically separate (A and B). Unlike nonhuman fission or deadly fission, conjoined fission is consistent with the idea that fertilization is a necessary and sufficient condition for the generation of human organisms because the moment of fertilization would be enough and all that is needed to account for every instance of human generation.

The continuity before and after fission is an advantage of conjoined fission compared with nonhuman fission and deadly fission. Another strength is that by allowing all human organisms to begin at fertilization, this theory avoids the ad hoc dual origins criticism of deadly fission. However, for different reasons, conjoined fission could also be criticized as ad hoc since it requires fertilization to have

11. Koch-Hershenov, "Totipotency, Twinning, and Ensoulment," 141.
12. Koch-Hershenov, "Totipotency, Twinning, and Ensoulment," 158.

dual effects. Some fertilization events generate one organism, and some fertilization events generate two organisms. Under normal circumstances, it is generally agreed, only one human organism will result from a fertilization event. There is no apparent physical or biological reason why an identical fertilization event would generate two organisms in some rare instances.

One could theorize that when fertilization generates two organisms, from the very beginning there was some currently unknown difference in the fertilization or in the interior orientation of the embryo. While it is entirely possible that this is the case, the fact still remains that conjoined fission would have difficulty explaining cases where monozygotic twinning occurs not because of some difference in fertilization or from some interior orientation of the embryo, but from exterior interference. For example, a probe may separate two cells of a single organism so that they develop as two distinct organisms.[13]

The above example points out that sometimes it is possible for an embryo to undergo fission even though in actuality it does not. However, in the standard case where a single human embryo grows into an adult human without the occurrence of fission, nobody would think that there was at any point more than one human organism. There would be no evidence—biological, philosophical, or theological—for such a belief.[14] Given that fission is so often dependent upon contingent circumstances that are exterior to the embryo, it seems to us ad hoc to suppose that there happen to be multiple organisms in one embryo in only those cases where fission does occur.[15] Given the challenges noted above, conjoined fission is unlikely to be an adequate account of embryo fission.

13. Carlson, *Human Embryology and Developmental Biology*, 49–50.
14. It seems to us that conjoined fission and fusion are much more likely outcomes on a four-dimensional view of personal identity. For example, see David Lewis, "Survival and Identity," and Derek Parfit, "The Unimportance of Identity," in *Personal Identity*, ed. John Barresi and Raymond Martin (Malden, MA: Blackwell Publishers, 2003), 144–167, 292–317. However, if the identity conditions of the organism are related to the substance, such as in three-dimensional views of personal identity, then conjoined fusion seems an unlikely possibility. See, for example, Patrick Lee and Robert George, *Body–Self Dualism in Contemporary Ethics and Politics* (New York: Cambridge University Press, 2008), 4–49; Christopher Tollefsen, "Experience Machines, Dreams, and What Matters," *Journal of Value Inquiry* 37.2 (June 2003): 153–164, doi: 10.1023/A:1025324410044; and Eric Olson, "An Argument for Animalism," in Baresi and Martin, *Personal Identity*, 318–334.
15. One could object that this is not ad hoc, just as Einstein's theories that patched up Newtonian physics were not ad hoc. The difference is that Einstein proposed theories that unified diverse phenomena. Thus, he was proposing a simpler explanation (in terms of the number of mechanisms proposed). Conjoined fission takes a single phenomenon of fertilization and gives it two different mechanistic effects (one embryo sometimes, two at other times) with no apparent reason. The dual fertilization effects do not explain any phenomena except for the theoretical conjoined fission. Since conjoined fission creates a more complex fertilization mechanism whose only purpose is to explain conjoined fission, the theorized dual effects of fertilization could rightly be characterized as ad hoc.

Regulative Fission

A final possible explanation is regulative fission.[16] Similar to conjoined fission, this theory indicates that a human organism is created at fertilization and that there is continuity between organisms before and after fission. In regulative fission, one organism is maintained through the fission event (A), but a new organism (B) is generated from cells that separated from organism A. Since some human beings are generated at fission, fertilization is not a necessary condition for the generation of human organisms. However, it could still be a sufficient condition because nothing in this theory explicitly prohibits human generation from happening at fertilization, as it mostly does. In other words, there is some principle of continuity that is both necessary and sufficient for human generation, but there are multiple different processes by which this principle can "get started," of which fertilization and fission are two.

The continuity before and after fission is an advantage of regulative fission compared with nonhuman fission and deadly fission. In addition, this is the explanation for fission provided by development biology textbooks. Another major strength of regulative fission is that it is based on a long-standing principle of developmental biology called regulative development, that is, the ability of an organism to adapt to gains or losses of cells.[17] For example, when the human organism consists of just two cells, it is possible to destroy one cell and still have normal development. This contrasts with mosaic development (as seen in organisms such as the roundworm) where eliminating cells results in losses of structures that those cells were destined to become.

According to the principle of regulative development, before fission occurs, there is one integrated organism with interdependent and subordinate parts. When some of the cells become separated from the original organism, it adapts to the loss and continues development normally. The separated cells adapt to the loss of the organism they came from and form a new organism with a new integrating center. The exact reason for fission in particular cases is uncertain, but it may be due to an embryo's difficulty in integrating all its cells into a complete whole.[18] When one integration center is insufficient, a second center of integration will manifest, thus resulting in two organisms. One way a single integration center could become insufficient is if there were a material defect (perhaps caused by a physical force) that causes some cells of the embryo to be physically separated from the rest of the cells.[19]

16. Koch-Hershenov, "Totipotency, Twinning, and Ensoulment," 142.

17. This principle was first developed by Hans Driesch in 1891. Hans Driesch, "The Potency of the First Two Cleavage Cells in Echinoderm Development. Experimental Production of Partial and Double Formations," *Zeitschrift für wissenschaftliche zoologie* 53 (1891): 160–184.

18. Judith Hall, "Twinning: Mechanisms and Genetic Implications," *Current Opinion in Genetics and Development* 6.3 (June 1996): 343–347, doi: 10.1016/S0959-437X(96)80012-8.

19. On the other hand, if two integrating centers were already present, it may be the case that the embryo tries to physically separate them. This type of explanation would be consistent with conjoined fission theory.

Another strength of regulative fission is that it allows the principle of regulative development to be applied consistently whether cells are destroyed or removed (such as in fission). In both cases, the embryo adapts to the loss of cells and continues existing. In contrast, in nonhuman and deadly fissions, an embryo does not adapt. In nonhuman fission, no human organism is present to adapt to the loss of cells. Regulative development will occur later in the embryo, and perhaps if cells are destroyed, but for some reason it does not occur during fission. Nonhuman fission requires regulative development to apply in all circumstances other than fission, where a new, unknown biological principle is needed. Similarly, in deadly fission, regulative development will occur if cells are destroyed, but when cells are just removed, regulative development does not take place, and the human organism dies instead, creating two new ones in its place. Again, deadly fission requires regulative development to apply in all circumstances other than fission, where a new, unknown biological principle is needed. A final strength of regulative fission is that it easily explains why adult human beings cannot split, as it is well known that regulative development decreases over time.

Similar to deadly fission, regulative fission could be criticized because it proposes dual origins. However, varying origins are not a problem for regulative fission, as the principle of regulative development, not ad hoc explanations, is being used in this theory.[20] In fact, regulative fission has the advantage of not needing to invent new biological principles.[21] The vast majority of human beings still begin at fertilization, which remains the natural mode of generation. The generation that occurs at fission is only a side effect of the incredible flexibility of the cells of the early human embryo. This flexibility allows the human embryo to undergo a significant regulative developmental event when it tries to save itself from an unusual circumstance causing it to split.

While it may be unusual to think that not all humans begin at fertilization, it fits with the biological data that we have of organisms that are much less complex than adult human beings but have a similar or greater level of morphological complexity than human embryos. For example, the hydra is a small organism just a few millimeters in length. It reproduces through a process called budding when a small piece separates from the adult organism. Similarly, some algae reproduce through a process called fragmentation where the adult organism splits into multiple smaller pieces. While there are some differences between these examples and fission, they demonstrate that similar modes of reproduction are not unprecedented.

Regulative fission provides an explanation for the biological event of fission that is consistent with current biological principles without the need to create any new ones. The other three fission theories (nonhuman, deadly, and conjoined) are

20. Regulative fission reveals another major flaw in the nonhuman twinning theory. Nonhuman twinning assumes that the change from being able to twin to being unable to twin is a substantial change since adult human beings cannot twin. However, there is no reason to believe that we cannot have different abilities at different developmental stages. This would be like saying that we are not human in the womb, because human persons cannot receive oxygen through their belly button.

21. Carlson, *Human Embryology and Developmental Biology*, 54.

unheard of in biological texts and would require novel biological theories. Nonhuman and deadly fissions are also inconsistent with the principle of regulative development in human beings. While the other theories are logically possible, they are significantly less likely.

Embryo Fusion

In embryo fusion, two embryos merge in the womb, resulting in a single embryo. This fusion presents possibilities similar to those raised with monozygotic twinning.[22] There are at least four ways to account for this process, which we refer to as nonhuman, deadly, conjoined, or regulative fusion, and many of the strengths and weaknesses are similar to those of the fission arguments.[23]

Nonhuman Fusion

According to nonhuman fusion theory, the original embryos (A and B) are not organisms or at least not human organisms. When they fuse, a new organism is eventually generated (C). Nonhuman fusion argues that the human embryo cannot be a human organism when fusion is possible, as humans cannot fuse together.[24] According to this explanation, fertilization is neither a necessary nor a sufficient condition for the generation of human life. As with nonhuman fission, nonhuman fusion cannot be correct, because it does not acknowledge the continuity between a pre-fusion and a post-fusion embryo, and it is inconsistent with the biological principle of regulative development.

Deadly Fusion

Deadly fusion is prominent among defenders of the humanity of the human embryo and states that when two organisms (A and B) undergo fusion, they die and create a new organism (C) that is distinct from both A and B. According to this explanation, fertilization is not a necessary condition for the generation of human life, because humans can be generated by some process other than fertilization. Unlike in nonhuman fusion, fertilization could be a sufficient condition as it does generate human organisms A and B. However, the theory suffers from the problem of ad hoc dual origins, it does not acknowledge the continuity between a pre-fusion and a post-fusion embryo, there is no biological data to support the death of both original embryos, and the theory needlessly posits an additional organism. Given these challenges, deadly fusion is very unlikely to be an adequate account of embryo fusion.

Conjoined Fusion

Conjoined fusion is the idea that organisms A and B are distinct prior to and after fusion, but after fusion they share the same matter (AB), whereas prior to fusion

22. Rose Hershenov and Derek Doroski, "Twin Inc.," *Theoretical Medicine and Bioethics* 39 (August 2018): 302, doi: 10.1007/s11017-018-9461-0.

23. In the fusion events examined here, the nature of the pre-fusion embryos is the same, so either both would be organisms or neither would be an organism. It is possible to have one pre-fusion entity that is an organism and another that is a non-organismal group of cells. In this scenario, the organism just absorbs the non-organismal cells through regulative development.

24. Hershenov and Doroski, "Twin Inc.," 303.

they did not. Conjoined fusion is consistent with the idea that fertilization is a necessary and sufficient condition for the generation of human organisms. The major weakness of this theory is that when two embryos fuse into one embryo, there is no evidence of two organisms being present.[25] In short, the results of the fusion of two embryos most reasonably suggest that just one organism remains. Therefore, conjoined fusion cannot be correct.

Regulative Fusion

In regulative fusion, there are two distinct organisms (A and B), and one of them absorbs the other with only one remaining (A). Embryo A attempts to adapt to the availability of cells from embryo B. If embryo A uses enough cells from embryo B, it will end up disrupting the integration of embryo B and thus killing that embryo. Regulative fusion would be analogous to a person with unhealthy organs obtaining transplant material by slowly removing organs from another human being. Once enough organs are removed from the second person, he or she dies, and the first person contains organs that were originally part of the second person. Regulative fusion is the standard explanation in developmental biology textbooks and the only plausible theory where fertilization could be a necessary and sufficient condition for the generation of human organisms. Even so, if regulative fusion is correct, human generation could still occur through means other than fertilization, although the theory itself does not imply other means of human generation.

Regulative fusion can consistently apply the principles of regulative development (as would conjoined fusion) whether small or large numbers of cells are added to an organism.[26] Conversely, nonhuman fusion and deadly fusion both predict that when a large number of cells are added from another embryo, the original embryos will die and neither embryo incorporates the cells. Thus, these theories either predict that regulative development works with small numbers of cells, then for unknown reasons, ceases to work for larger numbers of cells, or they must deny the principle of regulative development. Regulative fusion is the most plausible theory by far, and if it is correct, the simplest explanation would be to hold that regulative development applies equally to both fusion and fission. If regulative development occurs during fusion, it would be unnecessary to appeal to a new principle of fission like those introduced in the other theories.[27]

25. It should be noted that something analogous to conjoined fusion may occur in the case of conjoined twins. In this circumstance, the two organisms are joined, and the fact of their being two organisms is apparent. This conjoining is different from conjoined fusion where only one organism is apparent after fusion.
26. We are assuming here that the correct type of cells are added. Not all types of cells will be incorporated at the embryonic stages.
27. It is possible that regulative fission and fusion are correct, but one or more of the other theories is also correct, although perhaps less frequent. For example, God could sometimes choose to infuse two souls at fertilization, thus resulting in conjoined fission. However, as regulative theory is the most likely option and can currently explain all of the relevant phenomena, we see no reason to believe that any of the alternative theories apply to fission and fusion.

Fertilization as a Necessary and Sufficient Condition for Human Generation

If regulative fission and fusion are correct, fertilization is not a necessary condition for human generation, as some humans are created in the fission process.[28] However, regulative fission and fusion are consistent with fertilization as a sufficient condition for human generation as they do not propose any examples of fertilization that do not result in a human organism (table 1). One could object to the idea that fertilization is not necessary for human generation in regulative fission and fusion by pointing out that some fertilization event must happen for any fission event to occur. However, while fertilization may be practically necessary for human generation, it is not a necessary part of every *generative process* of a human being. Fertilization generates embryo A. Once embryo A is created, the generative process involving fertilization is complete. Next, embryo A splits into embryos A and B. This fission is a separate generative process that creates embryo B.

Consider the following example that illustrates more clearly what we mean when we say, "Fertilization is not necessary for human generation." Assume that Ford has only one existent process by which it assembles the Model T; we will call this process X. Therefore, it is practically necessary that all Model Ts must be made by process X. There may be many ways the vehicle could be put together (X, Y, or Z), but because of circumstance, process X is Ford's only existing method of producing it; therefore, it is necessary that Model Ts be made by process X. This is merely a product of external circumstance and is not due to some truth about the constitution of the Model T. Similarly, we maintain that fertilization may be necessary for human generation as a practical matter, like being created by process X is necessary for the Model T. But we do not think that generation by the process of fertilization is a necessary part of all processes that generate human life, even if by practical necessity there must be some fertilization event that supplies the material for a different process of human generation to then take place.

Cloning, also known as somatic cell nuclear transfer, is another example of a generative process that is not necessary for human generation. In the Roslin version of SCNT, the nucleus of an oocyte is removed. The enucleated oocyte is then fused with a nonreproductive cell (i.e., a somatic cell) such as a skin cell. The new cell is stimulated to start development, and the resulting organism is a clone of the person who donated the somatic cell. This process has already been used multiple times to create human clones, although all of them were killed at early embryonic stages.[29] SCNT shows that even in humans, it is possible to have a generative process outside fertilization even if there was a fertilization event that supplied the

28. It should be noted that regulative fusion is consistent with fertilization as a necessary condition of human generation. However, regulative fusion does not prove fertilization is a necessary condition.

29. Young Chung et al., "Human Somatic Cell Nuclear Transfer Using Adult Cells," *Cell Stem Cell* 14.6 (June 2014): 777–780, doi: 10.1016/j.stem.2014.03.015; Masahito Tachibana et al., "Human Embryonic Stem Cells Derived by Somatic Cell Nuclear Transfer," *Cell* 153.6 (June 2013): 1228–1238, doi: 10.1016/j.cell.2013.05.006; and Jose Cibelli et al., "Rapid Communication: Somatic Cell Nuclear Transfer in Humans: Pronuclear

Table 1

Competing Theories's Views on Fertilization as a Condition for Human Life

Theory of Generation	Fertilization is a Necessary Condition	Fertilization is a Sufficient Condition
Fission		
Nonhuman	No	No
Deadly	No	Possibly
Conjoined	Possibly	Possibly
Regulative	No	Possibly
Fusion		
Nonhuman	No	No
Deadly	No	Possibly
Conjoined	Possibly	Possibly
Regulative	Possibly	Possibly

material that enabled a human to be generated. To take another example, God could create a human embryo in a woman's womb by causing the egg to develop without fertilization. This human embryo may not be materially different from any other embryo even though there is no causal link to a fertilization event.[30]

It should not be shocking that fertilization is not necessary for human generation, as there are other examples of species where this is the case. For example, in hymenopteran insect orders (bees, ants, wasps), fertilization of the queen's eggs results in female workers. Fertilization plus royal jelly results in a female queen. If the eggs of the queen or female workers are not fertilized, male drones result. Here we see that it is possible for a species to exist where fertilization is only one way for generation to occur.

Although living organisms may come to be in a variety of ways, the way in which any particular kind of organism is generated may be distinct from what defines when an organism begins. Fertilization may be the way a human organism normally comes to be, but fertilization itself cannot be what defines when life begins. Regulative fission and fusion ultimately support the idea that fertilization is

and Early Embryonic Development," *e-biomed* 2.5 (November 2001): 25–31, doi: 10.1089/152489001753262168.

30. Interestingly, this spontaneous development of the egg is one possible way that Jesus's conception might have occurred. We thank Mark Miravalle for confirming this as a possibility. Another possibility is that God made a special creation of sperm that fertilized Mary's egg. Either way, Jesus was conceived through a generative process that is not normally used (and thus not normally necessary) for human generation.

central to human life because they account for the fact that most human organisms are generated through fertilization, but these theories also recognize that there are some instances where human organisms do not come to be by fertilization. We wish to be clear that even though regulative fission shows that human life does not universally take place through fertilization, only 3.3 percent of births involve twins or higher-order multiples.[31] Even when regulative fission does occur, half of the resulting human organisms were originally generated from fertilization.

We have now seen that regulative fission and fusion are the most plausible explanations of these processes. Consequently, while fertilization is the normal condition for human generation and may be a sufficient condition, it is not always a necessary condition, because sometimes human organisms appear to be created, such as in monozygotic twinning, by a process other than fertilization. Since regulative fission and fusion do not challenge the idea that fertilization is sufficient for human generation, they are compatible with the pro-life contention that the postfertilization embryo is a human organism and thus worthy of protection. In addition, while regulative development provides some explanation for the phenomena of fission and fusion, it is not clear what is required for the possibility of regulative development; to further understand the phenomena of human generation, it would be helpful to have deeper principles that further ground or explain how and why regulative development occurs. Although it is outside the scope of this paper to completely enumerate all those conditions that are necessary and sufficient for human generation, we hope this paper provides a foundation for and encourages further fruitful inquiry into this most important question of when life begins.

31. Joyce Martin et al., "Births: Final Data for 2019," *National Vital Statistics Report* 70.2 (March 2021): 9–10.