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# Pseudo-embryology and personhood: How embryological pseudoscience helps structure the American abortion debate

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## Abstract

There is a pseudo-embryology flourishing today, well nourished by popular science, religious ideologies, and the public media. Just as eugenics was a pseudoscience that influenced (and still influences) American popular culture and which was responsible for racist anti-immigration laws (such as the Immigration Restriction Act of 1924), pseudo-embryology is also influencing popular culture and legislation. This new pseudoscience promotes the belief that science supports current zygotic and fetal personhood movements as well as anti-abortion legislation. However, what often passes for science are actually ideological myths, often grounded in and supporting male superiority. Indeed, the first myth of pseudo-embryology is that fertilization is a masculine act that can be viewed as a classical hero narrative. The second myth is that fertilization is ensoulment, allowing it to displace the feminine act of birth as to when life begins. Here, DNA is seen to play the secular analogue of soul. The third myth is that the fetus in the womb is an independent autonomous entity and that birth merely moves the fetus from the womb to the outside world. This expresses the "seed-in-the-soil" myth that was also prevalent in ancient cultures. In this manner, masculine stories of fertilization are valorized while feminine narratives of birth are suppressed. So when public narratives discuss what "science" says about when human life begins, we are not really discussing science. Rather, we are allowing our discussions to fall back into tenacious ancient misogynist myths that have nothing to do with the conclusions of modern developmental biology.

## Key points:

- There is no consensus among biologists as to when personhood begins.
- Different biologists have proposed that personhood begins at such events as fertilization, gastrulation, the acquisition of an EEG pattern, and birth. Other scientists claim that the acquisition of personhood is gradual or that the question of personhood is not a biological one.

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- The “science” debated in public discussions is not the set of conclusions based on biological research. Political discussions of reproduction are often based on false culturally-based stories.
- Fertilization is falsely perceived as a race of sperm through a passive female, emphasizing male performance rather than interactions and mutual gamete maturation.
- The genome is falsely depicted as one’s soul, promoting the idea that fertilization is ensoulment. Genetic determinism is often assumed, and plasticity ignored.
- The fetus is falsely depicted as a seed in nutritive soil, autonomous from the mother. The joint nature of maternal and fetal physiologies and anatomies are marginalized.
- The false narratives combine to form a “pseudo-embryology” that influences our thoughts and laws.

**KEYWORDS**

abortion, fertilization, “when does human life begin”, personhood

An active pseudo-embryology is flourishing today, well nourished by popular science, religious ideologies, and the public media. Just as eugenics was a pseudoscience that influenced (and still influences) American popular culture and which was responsible for racist anti-immigration laws (such as the Immigration Act of 1924),<sup>1–3</sup> pseudo-embryology is also influencing popular culture and legislation. This new pseudoscience promotes the belief that science supports current zygotic and fetal personhood movements as well as anti-abortion legislation. However, what often passes for science actually consists of ideological myths, frequently grounded in and supporting male superiority. Indeed, the first myth of pseudo-embryology is that fertilization is a masculine act that can be viewed as a classical hero narrative. The second myth is that fertilization is ensoulment, allowing conception to displace the feminine act of birth as to when life begins. Here, DNA is seen to play the secular analog of the soul. The third myth is that the fetus in the womb is an independent autonomous entity, and that birth merely moves the fetus from the womb into the outside world. This scenario expresses the “seed-in-the-soil” myth that was also prevalent in many ancient cultures. In this manner, masculine stories of fertilization are valorized, whereas feminine narratives of birth are suppressed. So when public narratives discuss what “science” says about when human life or personhood begins, we are not really discussing science. Rather, we are allowing our discussions to fall back into tenacious ancient myths that have nothing to do with the conclusions of modern developmental biology.

## AN INTRODUCTION TO THE PROBLEM: WHEN DO SCIENTISTS SAY THAT AN INDIVIDUAL HUMAN LIFE BEGINS?

When Jon Stewart was grilling former Arkansas governor Michael Huckabee on The Daily Show, the 2012 presidential contender claimed, “Biologically, life begins at conception. That’s irrefutable from

a biological standpoint.” Moreover, Stewart let him get away with that.<sup>4</sup> Jon Stewart may have known the intimate details of American politics, but he obviously knew little about human embryology. He allowed Huckabee to present unchallenged the erroneous view that there is a scientific consensus that personhood begins at fertilization. Similarly, when the *New York Times* discussed issues of science and abortion, the article quoted politicians, not scientists.<sup>5</sup> “Life begins at conception,” said Representative Mike Johnson, who proposed the Unborn Child Support Act in Congress in August, 2022, “and this bill is a straightforward first step toward updating our federal laws to reflect that fact.”

Many people take for granted that all scientists believe that a separate human life, a person, is established at fertilization. A *Wall Street Journal* editorial by Rick Scott,<sup>6</sup> a senator from Florida, is titled, “Democrats: When Do You Think Life Begins?” and the subtitle is “Politicians dodge the question, but the scientific answer is clear: At the moment of conception.” He states, “It’s a conclusion grounded in faith and values, but also in science.”

As an embryologist and the author of a major textbook in embryology, I know that I can say very few things with absolute certainty. However, one thing I can say with absolute and total certainty is this: There is no consensus among biologists as to when independent human life begins.

So, first, let me briefly summarize six positions that are held by different groups of biologists, especially those scientists whose profession is the study of embryos.

*Some biologists claim that personhood begins as a zygote, a fertilized egg.* This view that an independent human life exists at fertilization is a “genetic” perspective of life, emphasizing the importance of the human genome. In this view of human life, a new individual is created when the genes from two parents combine to form a new genome with its unique properties. Geneticist Jerome LeJeune<sup>7</sup> wrote that “human life begins at the time of conception,” and embryologists Ronan O’Rahilly and Fabiola Muller write, “Fertilization is an important

landmark because, under ordinary circumstances, a new genetically distinct human organism is thereby formed.”<sup>8</sup>

The major assumption is that a living substance with a human genome has the potential to become an infant and therefore should be considered a person. Thus, R. M. Anderson writes that zygotes and early embryos are human because they possess “all the genetic stuff of full humanness.”<sup>9</sup>

This genetic perspective suggests that one of the possible places where personhood might begin is at fertilization. However, the assertion often made by anti-abortion, zygote rights, people<sup>10</sup> that, “Virtually every human embryologist agrees that life begins at first contact of sperm and ovum,” is not correct. Here are some other well-documented points of view.<sup>11</sup>

*An important view for many embryologists is that personhood begins at gastrulation.* To many scientists studying embryonic development, a human receives individual (but not independent) identity around Day 14, when the embryo completes a process called gastrulation. This is the stage where the cells of the embryo interact with one another such that they can no longer form identical twins. Each embryo can now give rise to only one child, and thus, many biologists and bioethicists consider gastrulation the point at which one becomes an individual.<sup>12–14</sup> As bioethicist Robert Green<sup>15</sup> wrote, “Only at gastrulation can we say that the lengthy process of individuation is complete.” This is the basis for the “Day 14 Rule” that presently allows research on human stem cells up until the time of gastrulation,<sup>16,17</sup> a view that has been supported by Britain’s Warnock Committee,<sup>18</sup> the Canadian Royal Commission on New Reproductive Technologies<sup>19</sup> (1993), the NIH Human Embryo Research Panel in the United States<sup>20</sup> (1994), and research agencies throughout the world. Indeed, Appleby and Bredenoord<sup>21</sup> conclude that “the 14-day rule is one of the most internationally agreed rules in reproductive science and medicine to date.”

*A third view is that personhood begins upon the acquisition of the human EEG pattern.* This “neurological” perspective sees the functioning of our central nervous system as the most important factor determining when one is a person.<sup>22</sup> Indeed, it offers a symmetry that if the loss of the human EEG (electroencephalogram) pattern determines the end of personhood<sup>23–25</sup> (i.e., death; even though the heart may still be beating), then the acquisition of the human EEG pattern should be considered the point when human personhood begins. Biophysicists Harold Morowitz and James Trefil<sup>26</sup> wrote that just as our species became human upon developing our cerebral cortex, we become human individuals when this cortex begins functioning. This is normally about 24–28 weeks of gestation.

The idea that rational consciousness defines who is a person has a longstanding history, going back to the philosophies of St. Aquinas, St. Augustine, and most prominently Boethius,<sup>27</sup> who defined a person as “an individual substance of a rational nature.” This view was also prominent in the naturalist epistemological tradition of Descartes, Locke, and Hume, for whom a person was an agent who possessed the ability of framing representations about the world, and thereby imagining plans and acting on them.<sup>28</sup> So the acquisition of the EEG pattern, too, is a legitimate view for the acquisition of personhood.

This stage of development is also the period where it might become possible for an embryo to perceive pain.<sup>29</sup> Neurological neuroanatomical studies have shown that the anatomical connections needed to transmit impulses from the peripheral sensory nerves to the brain, as well as the brain structures necessary to process those signals, have not developed until at or after 24 weeks of gestation.<sup>30</sup>

*Another prominent position is that personhood begins at or around birth.* The neurological view mentioned above brings us very close chronologically to the view that a fetus should be considered human only when it can survive outside the body of the pregnant person. Traditionally, the natural limit of such viability was imposed by the respiratory system: A fetus cannot survive outside the uterus until its lungs were sufficiently mature, which usually occurs at about 28–34 weeks of gestation.<sup>31</sup> Today, however, technological advances can enable an infant born more prematurely to survive with minimal lung capacity.

Advocates for other viewpoints have often downplayed birth as merely passing from one environment to another.<sup>32</sup> But birth is not merely a move from one environment to another; it is a fraught passage. While in the womb, the lungs, one of the last organs to form, did not have to function. Upon birth, pulmonary function is critical, and the first breath of air changes the anatomy of the heart, causing cellular tissues to separate the left and right sides of the heart, making pulmonary circulation possible.<sup>33–35</sup> When the first breath is drawn, changes in air pressure close the muscular wall of the ductus arteriosus. This stops blood from flowing from the aorta into the pulmonary artery. This increases the blood pressure in the left side of the heart, and this pressure is thought to close the foramen ovale, a hole between the right and left atria. This closure separates the pulmonary and systemic circulations. It takes nearly a week for the ducts to fully close. In this way, heart anatomy is altered, and respiratory circulation is shunted from the placenta to the lungs.

So birth is also a place where an independent biological life can be said to begin. Billboards and websites<sup>36</sup> may claim that at “18 days from conception, [a] heart begins to beat, with the unborn baby’s own blood.” But at 18 days, there is no heart to beat, as the heart-forming tube has neither looped nor formed its chambers. Moreover, this early heart rudiment pumps no blood (which does not differentiate until week 5).<sup>37</sup> While the fetus develops, it receives oxygen from maternal blood pumped to its placenta. Circulation to get oxygen from the lungs has not yet developed.<sup>38</sup> The fetal heart changes into the functional neonatal heart when the baby takes the first breath, and in many traditions, soul and breath are the same word.

To some scientists who claim birth as the stage when a human receives their personhood, the embryonic and fetal stages are preparatory. If a Lowes store were destroyed by a hurricane, they say, one would not claim that 100 homes were destroyed. Bioethicist Michael Sandel<sup>39</sup> also follows this view, writing, “Consider an analogy, although every oak tree was once an acorn, it does not follow that acorns are oak trees, or that I should treat the loss of an acorn eaten by a squirrel in my front yard as the same kind of loss as the death of an oak tree felled by a storm.” Moreover, despite the untrue pronouncements by a noted anti-abortion author that “from the first moment of

fertilization, human development is a *fait accompli*,<sup>40</sup> the human birth rate is surprisingly low. Less than 30% of cleavage-stage embryos come to term.<sup>41</sup>

*Last, many scientists feel that personhood is not a scientific category.* For many (if not most) biologists, the question of when an embryo becomes a “person” is not a scientific question. Like “race,” personhood is defined socially, not biologically.<sup>42,43</sup> In the United States of America, corporations are given legal “personhood” such that they can dispense funds to political candidates and organizations. Several animal rights organizations are attempting to make chimps, gorillas, and dogs “legal persons.” The concept of who is a person has differed in the Western world from time to time. There is no biological marker to personhood, and there is no “beginning” to life, because gametes are, themselves, alive. Therefore, to many biologists, personhood is an issue decided on emotions, upbringing, and politics, not science.

Given that there is a multiplicity of scientific points as to when an embryo can become a person, why are people (mostly politicians) saying that science has shown that personhood begins at fertilization? Let me put forth the following hypothesis: When we discuss ideas about when independent human life begins, we hardly ever talk science; we repeat myths. In addition, the first myth that gets repeated is that of fertilization. It is critical that we recognize that the popular fertilization story is a myth, because most Americans focus on this option when they discuss the origins of an independent human life.

## THE MYTHS OF REPRODUCTION

### The heroic myth of fertilization

#### The myth

Fertilization, as most Americans and Europeans understand it, is the saga of the sperm.<sup>44,45</sup> It is a hero myth centering on masculine prowess. Indeed, the sperm performs what Joseph Campbell and other mythologists have called “the hero’s journey.”<sup>46</sup> This motif of adventure and conquest is widespread throughout the world’s mythic traditions, and we have structured our narrative of fertilization around it. Like the hero, the founding sperm receives a call to adventure, crosses a boundary and leaves its kingdom, enters a netherworld of darkness, is challenged during an arduous journey, and after a final contest, wins the prize, and starts a new kingdom. Indeed, one of the most popular books<sup>47</sup> in this area tells us that “the sperm undergo a perilous journey,” and that “the successful sperm surround the prize.” The egg is the merely passive prize awaiting the successful sperm, and the female reproductive tract is merely the racecourse upon which the sperm compete.<sup>48,39</sup>

In America, fertilization, seen as a masculine act, has been elevated to become the creation of a new life, whereas birth, the quintessentially female act, has been demoted to being a mere trip from the uterus to the outside world. This myth valorizes male roles and diminishes the female roles.

#### The science

According to the science of developmental biology,<sup>49</sup> this story of fertilization as masculine prowess has very little to do with the actual process of human fertilization. First of all, the egg and the sperm are immature cells. The newly ejaculated sperm cannot find or fuse with an egg. It gains these abilities in the oviduct, when the oviduct cells bind the sperm and alter its cell membrane.<sup>50</sup> This process is called capacitation. Once capacitated, the sperm have the ability to sense the newly ovulated egg, which, with its associated cumulus cells,<sup>51</sup> is putting forth chemical signals that can attract sperm and cause the hyperactivation of sperm flagella.<sup>52,53</sup> The female oviduct is not a passive racetrack, and the egg and its cumulus are active in attracting sperm and exciting them to swim faster. Although the sperm needs its propulsion to pass through the cumulus cells and extracellular covering that surround the egg, it does not bore through, drill through, or penetrate the egg, itself. Rather, when the sperm finds the egg, it lies next to it, spooning, and then the membranes of the sperm and egg melt together, and the two become one.<sup>54,55</sup> Once inside the egg, the sperm cytoplasm contains the phospholipase C enzymes that mature and activate the egg, allowing it to complete its second meiotic division and renew protein synthesis.<sup>56</sup> Just as the oviduct and ovulated cumulus-oocyte complex activated the sperm, so the sperm now activates the egg.<sup>57</sup>

Fertilization is characterized by reciprocal maturation and activation. There is a competition in which only one sperm is successful, but neither the female reproductive tract nor the egg is passive. Fertilization is not a violent act, as is so often portrayed. Nor is the fastest sperm necessarily the successful sperm. Indeed, the first sperm to meet the egg is probably too immature to fuse with it, as it has not been capacitated.<sup>58</sup>

### The myth of the genomic soul

#### The myth

But why should anyone believe this fertilization myth? We have known about capacitation since 1951, and this knowledge is the basis for our in vitro fertilization techniques. The answer to why this belief is still so prevalent may lie in the second myth. This is the myth that DNA constitutes our soul, and that fertilization represents our ensoulment. We see evidence for this belief throughout our culture. The ads for 23 and Me and Ancestry.com tell us that our genes are our identity. Indeed, DNA has become the secular analog of the soul. We are told that genes make us who we are, and that the genome is our essence. We are told that, “the sauna is in the DNA of every Finn” and that “Hygge is in the Danish DNA.”<sup>59</sup> No they are not. They may be in their respective Nordic “souls,” but not in their nucleotide polymers. Dorothy Nelkin and Susan Lindee<sup>60</sup> write in *The DNA Mystique*: “DNA in popular culture functions, in many respects, as a secular equivalent of the Christian soul... In many popular narratives, individual characteristics and the social order

both seem to be direct transcriptions of a powerful, magical, and even sacred entity, DNA.” Furthermore, they claim, “the similarity between the powers of DNA and the Christian soul ... is more than linguistic or metaphorical. DNA has taken on the social and cultural functions of the soul. It is the essential entity—the location of the true self—in the narrative of biological determinism.” DNA is seen as our essence, that which determines who we are, that which makes us individuals, and that from which we can be resurrected after death.

The idea that DNA is our essence runs so deeply in American culture that it goes unquestioned.<sup>61</sup> When Jaguar sells its cars, it emphasizes its “racing DNA,” and the advertisement for the Infinity claims that “while some luxury sedans just look like their elders, ours has the same DNA.” The *Newsweek* advertisement for the midsize Hummer closed with tagline, “Same DNA, Smaller chromosomes.” It might be smaller, but the essence stayed the same. When Ancestry.com asks for your DNA, it tells you that it could “answer, once and for all, ‘what it is that makes you, you?’”

In addition, this DNA, we are told, controls our behavior. For example, in 2010, several newspapers reported that scientists had found that mutations in a particular gene make one liberal or conservative. Fox News<sup>62</sup> announced that “researchers have found the liberal gene” and told its listeners, “Don’t hold liberals responsible for their opinion—they can’t help themselves. A new study has concluded that ideology is not just a social thing; it’s built into the DNA, borne along by a gene called DRD4.” Yet, the gene in question was not shown to make one liberal or conservative. This paper<sup>63</sup> had not done such a study. The gene was involved in neurotransmitter synthesis. The rest was conjecture and fantasy. Variations of another gene, COMT, we were told, make one either a “warrior or a worrier,” and the health-care section of one newspaper<sup>64</sup> informed us that Ozzie Osbourne “has been able to survive years of the rock ‘n roll lifestyle because he has a rare combination of both warrior and worrier genes.” The American public is being informed continuously that DNA is our essence, our soul, and the basis of our selfhoods.

This view that DNA is our soul has very important ramifications. For if our genome is our soul, and if we acquire this genome at fertilization, then fertilization is ensoulment.

This conjunction of fertilization and ensoulment was evident in the extremely popular 1990 *Life Magazine* article showing Lennart Nilsson’s iconic photographs<sup>65,66</sup> of embryos and fetuses. The article tells us with anonymous authority,<sup>67</sup> “The result of fertilization is a single nucleus that contains an entire biological blueprint for a new individual, genetic information governing everything from the length of the nose to the diseases that will be inherited.”

We see the myth of fertilization as ensoulment in antiabortion websites such as StandUpGirl, which says,<sup>68</sup>

Fertilization marks the beginning of a new, individual life. At fertilization, the DNA of a single sperm and ovum merge to create the genetic blueprint for a new human being. Once the DNA has recombined and the single-celled ovum begins to divide, things really begin to roll.

The Catholic Church uses this supposed science as evidence for its doctrines, bringing fertilization into explicit contact with ensoulment.<sup>69</sup>

From the time that the ovum is fertilized, a new life is begun which is neither that of the father nor of the mother; it is rather the life of a new human being with his own growth. It would never be made human if it were not human already. To this perpetual evidence ... modern genetic science brings valuable confirmation. It has demonstrated that, from the first instant, the programme is fixed as to what this living being will be: a man, this individual-man with his characteristic aspects already well determined... This teaching remains valid and is further confirmed, if confirmation were needed, by recent findings of human biological science which recognize that in the zygote resulting from fertilization the biological identity of a new human individual is already constituted. Certainly no experimental datum can be in itself sufficient to bring us to the recognition of a spiritual soul; nevertheless, the conclusions of science regarding the human embryo provide a valuable indication for discerning by the use of reason a personal presence at the moment of this first appearance of a human life: how could a human individual not be a human person?

We also see the notion of gamete ensoulment in the writings of philosophers such as Robert George,<sup>70</sup> who states the case that

Fertilization produces a new and complete, though immature, human organism. ... The embryonic, fetal, infant, child, and adolescent stages are stages in the development of a determinate and enduring entity—a human being—who comes into existence as a single cell organism... The direction of its growth is not extrinsically determined, but is in accord with the genetic information within it.

We are told constantly that genes are our essence, and that we are the epiphenomena of our genes. But this is not science. This is ideology.

## The science

Three major sets of substantial scientific evidence rule out such genetic determinism: (1) the incompleteness of genetic causality in common phenotypes, (2) developmental plasticity, and (3) developmental symbiosis.

### *Incompleteness of genetic causality in common phenotypes*

The phenotype is the observable set of traits that characterize an individual. We are told that our phenotypes—both our healthy phenotypes

and our medical disorders—are all genetic. This is advertising, not science. Some of this advertising came from science, itself. The human genome project made such claims loudly and publicly. Walter Gilbert<sup>71</sup> proclaimed, “When we have the complete sequence of the human genome, we will know what it is to be human.” Richard Dawkins<sup>72</sup> claimed that DNA is our essence, and that animals are but mere “survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes.”

However, the two great unexpected findings of the human genome project are that (1) genes contribute a rather small fraction of difference in common phenotypes, and (2) that genes are of relatively little significance in common disease states.<sup>73</sup> For example, GWAS studies<sup>74</sup> showed that there are 314 genes that predispose us to heart attacks. Taken together, however, they account for only 3% of the differences between people.<sup>75</sup> Most causes of heart attacks are environmental—diet and paucities of exercise. Similarly, there are 52 known genes associated with differences in human intelligence. Taken together, these account for less than 5% of the differences between people.<sup>76</sup> Most differences in intelligence are environmental and social—how you are trained to use your brain. Genes do not determine who we are. They give us the parameters to become many different things in various contexts.

Newspapers report that scientists have found the genes for homosexuality, schizophrenia, bipolar disorder, musical ability, and sadness. We have not. Often, the results of one study will be touted by the press; but when further studies are done, the first study was shown to be a statistical aberration. These further studies do not get reported by popular media. We rarely hear that the gene for depression has, in fact, been lost. But it has.<sup>77</sup> Similarly, the “gay gene,” first mooted in 1993, has never been found.<sup>78,79</sup> But it lives on in public discourse as if it were true.<sup>80</sup> The public remembers stories about how human behaviors are determined by our genes.

There is one gene, however, that is found in a mutated form throughout the entire human population. This mutant gene can give each person a painful and eventually lethal genetic disease. It is the human gene encoding the enzyme gulonolactone oxidase. This mutation in chromosome 8 blocks the synthesis of vitamin C and thus prevents normal cartilage formation. Without the environmental supplementation of ascorbic acid from fruits and other sources, we would suffer severe connective tissue disease as youngsters,<sup>81,82</sup> and all humans would likely die of scurvy before reproducing. The genome is but one factor in producing our phenotype. It is neither our soul nor our essence.

#### *Developmental plasticity*

Until the early days of this century, it was generally believed that the genome established at fertilization was passed on to each cell of the body, and through the above-mentioned genetic determinism, the phenotype was a readout of the genotype. The environment was not thought to play an instructive role in normal development. If the environment played any role, it was either permissive or teratogenic.<sup>83–85</sup> However, we now understand that developmental plasticity—the ability of larval or embryonic organisms to react to environmental input with a change in form, physiology or behavior—is ubiquitous. A single

genome can generate different phenotypes depending on environmental cues. Some of these are striking—the dietary difference that can change a small sterile worker bee or ant into a large fertile queen, the temperature-mediated gene expression that determines sex in turtles and alligators, or the predator-dependent cues that induce protective structures and toxins in numerous species.

In laboratory rats, maternal licking and grooming causes serotonin to be made in the pup, and this hormone changes the DNA methylation pattern of the gene encoding the stress-responsive glucocorticoid hormone receptor in the young rat’s brain. The addition of a methyl group to the DNA molecule does not change the DNA sequence but inhibits the expression of the gene. Without maternal care, the glucocorticoid receptor gene is methylated, and the glucocorticoid receptor protein is not produced in the brain regions. When these rats mature, the adults that received maternal care are less anxious and react differently to stressful situations than those genetically identical rats who did not receive the licking and grooming from their mothers.<sup>86</sup>

Numerous human phenotypes are created by environmental causes. The abovementioned changes in heart anatomy at birth are some of them. The formation of the patella bone,<sup>87</sup> the proper occlusion of teeth,<sup>88</sup> and the exercise-induced enlargement<sup>89</sup> of our musculature are also pressure-induced phenotypes. Epidemiological and anatomical data from humans<sup>90–92</sup> have indicated that prenatal nutrition influences the adult offspring’s susceptibility to cardiovascular disease, obesity, cancers, and type 2 diabetes. Waterland and Jirtle<sup>93</sup> provided evidence that DNA methylation might be the critical link by which nutritional deficiencies during a woman’s early pregnancy might cause chronic disease in her adult offspring. The most astonishing example of our developmental plasticity is the development of our immune system, wherein the cells of our immune system differ depending on which microbial predator is sensed. Thus, environmental circumstances during human development play critical roles in determining our physical and behavioral phenotypes, as well as making us more prone to have certain diseases as adults.

Even identical twins—with the same DNA in their genome—are very likely to be *discordant* in behavioral phenotypes and disease risks.<sup>94–96</sup> Gould<sup>97</sup> makes the case that the most celebrated cases of human identical twins—conjoined twins—often have distinct personalities despite having the same genomes and identical environments. Even cloned animals—where the genome is known to be identical—have different physical and behavioral phenotypes. Ian Wilmut and colleagues,<sup>98</sup> who led the research leading to Dolly, noted that when four sheep had been cloned from the same embryo, “the four are genetically identical, yet they are very different in appearance and character.”

#### *Developmental symbiosis*

Another factor in producing phenotypes is symbiotic bacteria. Although experiments cannot be done in humans, bacteria in mice are essential for maturing the gut neurons necessary for peristalsis,<sup>99</sup> forming the auditory neurons necessary for hearing,<sup>100</sup> generating the blood vessels that surround the small intestine,<sup>101,102</sup> inducing the gut-associated lymphoid tissue,<sup>103–105</sup> and inducing social behaviors.<sup>106,107</sup> Indeed, evidence in humans shows that bacteria may

be essential for healthy cognition and mental states.<sup>108–110</sup> One's microbiota is not established until birth (as we pass through the birth canal or otherwise become colonized by bacteria) and is then modified thereafter. It contributes in major ways to our physiological, immunological, and behavioral phenotypes.<sup>111,112</sup>

Environmental agency is critical in forming and maintaining our phenotype. The genome does not encode a particular genotype but rather establishes the range of physical and mental phenotypes that can be elicited by the environment. Thinking of the genome as our essence or as the secular analogue of soul is ideology, not science.

## The myth of intrauterine isolation

### The demythologization of birth

As the fertilization and genomic ensoulment narratives have been elevated, the importance of birth has been minimalized. Birth used to be the obvious beginning of a new life. In addition, it is a heroic undertaking. Although men might imagine their sperm in mortal combat, women endure an actual life-threatening and often intensely painful, exhausting, and exhilarating physical ordeal. Until the past century, childbirth was extremely dangerous to both the baby and to the woman, and it remains a precarious time today. Death of the mother in childbirth was about 1.0%–1.5% in colonial America, and it was the source of much anxiety. In their letters, some women referred to childbirth as “the Dreaded appreciation” and “the greatest of earthly miseries.”<sup>113</sup> Fearing her death at childbirth, Puritan poet Anne Bradstreet wrote to her husband, “How soon, my Dear, death may my steps attend, How soon't may be thy lot to lose thy friend.” She told her beloved that she does not mind his remarrying after her death; but if she dies, he must care for the child, even if the stepmother does not. Childbirth has traditionally been a time fraught with existential anxieties. Now, though, birth is seen as a routine “delivery,” mostly by those who do not have to go through it. The baby needs only to be taken from the uterus like a bun from the oven.

### The myth

Western medicine historically has often represented an intrauterine fetus as an autonomous entity within a container.<sup>114</sup> The fetus was inside, but not a part of, the pregnant woman. Rather, the uterus has been considered just a vessel containing the fetus. This model of an autonomous fetus within a nutritive container (the seed in a flowerpot model) is not so much demonstrated as assumed. The soil nourishes and sustains the seed, but the soil and the seed are always separate entities.<sup>115</sup> Kingma<sup>116</sup> noted that the fetal container view is the dominant representation of human pregnancy, and that it is largely assumed by contemporary Western culture. For example, Smith and Brogaard<sup>117</sup> write that the fetus is inside a woman in the way “a tub of yogurt is inside your refrigerator.” Similarly, Oderberg<sup>118</sup> (2008, p. 266) wrote that the embryo is “an organizational unity that is not a part of its host.”

This has certainly been a part of the photographic tradition that abstracts the fetus from the mother and uterus.<sup>119</sup> Here, the fetus is seen as an autonomous, self-constructing agent that is separate anatomically and physiologically from the mother. Stabile<sup>120</sup> and Taylor<sup>121</sup> documented the erasure of the maternal environment from public photographs of embryos. This was certainly the case in *Life Magazine's* presentation of Lennart Nilsson's photographs as well as the 2003 *Newsweek* photo-essay, the cover of which shows a human fetus, wrapped in its amnion, as if floating in space.<sup>100</sup> Even its umbilical cord has been digitally removed.

Much of the literature for restricting abortion has also assumed the model of an autonomous fetus within a separate container.<sup>122</sup> The normalization of the fetal container model is perhaps most evident in discussions of surrogacy,<sup>123</sup> which epitomize the view of pregnancy as a “tenant-niche relation.” Here, we find descriptions of pregnant women as “bearers,” “containers,” “incubators,” “hatcheries,” “plumbing,” “rented property,” or “alternative reproductive vehicles.” Surrogate mothers do not have a child but merely “utilize” their bodies to deliver a service. The fetal container model is crucial in enabling the claim that the “biological parents” of a child are the genetic parents, denying the significance of gestation and harking back to a flowerpot view of pregnancy: the uterus containing an embryo belonging to the commissioning parents, and which the surrogate mother will simply incubate until it is ready to be given back.

The idea of the seed in the soil is another ancient myth bearing the marks of male domination. Specifically, as embryologist and historian Joseph Needham<sup>124</sup> showed, this myth embodies the idea that inheritance comes solely from the male seed. The seed (*sperma* and *semen* are the Greek and Latin words for seed, respectively) was sown into the woman's furrow, wherein it would then be nourished. The woman merely provides nutrition. This is seen in sources as diverse as Aeschylus and Aristotle.<sup>125,126</sup> In Aeschylus' *Eumenides*,<sup>127</sup> Apollo defends Orestes from the charge of killing his mother by stating that mothers are not blood relatives of their children. Rather, they are strangers to their offspring, like the soil that nurtures seeds. “Not the true parent is the woman's womb that bears the child; she doth but nurse the seed new-sown: the male is parent; she for him, as stranger for a stranger, hoards the germ of life.”

Moreover, as Needham points out, a perspective that sees all inheritance as coming from the male promotes the classic warfare model of killing the men and raping the women: any progeny would be that of the soldiers. A second source, perhaps dependent on the first, is the Christian tradition as seeing Mary as the perfect container for the Holy Spirit, The Vessel of Honor, the Tabernacle in whom Jesus dwelt. This is a model endorsed by St. Thomas<sup>128</sup> and repeated on numerous websites.

### The science

The real science is far more interesting. Several investigators<sup>85,92,129,130</sup> have concluded that neither the mother nor the fetus has a separately delineated anatomy, immune system,



or physiology. In fact, this contemporary perspective on pregnancy shows that neither the mother nor the fetus is a traditional biological “individual.” Rather, this scientific perspective proposes that we view the fetus and the mother as a single organism, the *gravida*, wherein the fetus is a component that is fully integrated anatomically and physiologically with the mother.

Although the mythic perspective is to view the fetus as anatomically separated from the uterus, developmental biology shows that the conceptus (embryo/fetus) produces cells that intermingle with those of the uterus. The placenta is an organ that is made from both the trophoblast tissue of the embryo and uterine tissue of the mother. The cells interact to make this organ, and no clear anatomical line separates them. Rather, fetuses and pregnant organisms may have parts in common—namely, the arteries, veins, membranes, and glutinous tissue (Wharton’s jelly) that form the umbilical cord. Moreover (unlike most photographic representations), the fetus and pregnant organism are not separated by a cavity. Rather, fetal cell lineages colonize the maternal spiral arteries such that maternal and fetal cells intermingle and directly border each other. In the anchoring villi, fetal and maternal connective tissues form one tissue that holds the placenta together. Fetal and maternally derived tissue cannot be readily separated. There is no clear boundary marking the place where the fetus ends and the uterus begins.<sup>131,132</sup> In addition, the bidirectional flow of fetal stem cells into the mother and maternal blood cells into the fetus appears to create “a permanent connection that contributes to the survival of both individuals.”<sup>133</sup> Thus, *anatomically* the fetus forms a part of the mother. It is not a tenant inside a vessel.

Physiologically, the pregnant woman (the *gravida*) and the fetus interact to make a common physiological environment. The fetus, being nested within the pregnant woman and connected to her by their shared circulatory systems, is subject to the diet, stress levels, and other factors influencing the pregnant woman’s physiology. In addition, reciprocally, the fetus, being connected to the woman, changes her physiology, just as a well-functioning pancreas or ovary would. The embryo induces numerous physiological changes in the mother.<sup>134</sup> In this, the trophoblast, in particular, is important. In addition to its being a structural component of the embryo, it functions as endocrine organ. The trophoblast from the embryo makes numerous hormones that are shared between *gravida* and fetus. These include human chorionic gonadotropin (hCG), human chorionic corticotropin, as well as several pro-opiomelanocortin-derived peptides, including  $\beta$ -lipotropin-,  $\beta$ -endorphin-, and  $\alpha$ -melanocyte-stimulating hormone. The hCG hormone stimulates the corpus luteum in the ovary to make progesterone during the first trimester. This progesterone is critical for limiting the immune response against the embryo and for making the uterine tissue pliable. During the third trimester, the trophoblastic cells produce large quantities of placental lactogen, a hormone thought to have a role as a regulator of lipid and carbohydrate metabolism in the mother. Human placental lactogen also makes the *gravida* body less sensitive to the effects of insulin, a hormone that moves glucose from the bloodstream into the cells, leaving more glucose available in the pregnant woman’s bloodstream to nourish the fetus.

As reviewed in Napso et al.,<sup>134</sup> alterations in the maternal cardiovascular system begin very early in gestation and ultimately lead to systemic vasodilation and increased blood perfusion of maternal organs, including the gravid uterus. Systemic vascular resistance is reduced by 25%–30% and accompanied by a 40% increase in cardiac output during human pregnancy. There is also an increase in the numbers of red blood cells in the mother during pregnancy, due to the proliferation of erythroid progenitors in the spleen. Lung tidal volume and ventilation increase by 30%–50%, and the mother’s kidneys and other organs adapt to this new situation. Overall, these adaptations ensure the well-being of the mother, while also providing an adequate blood flow to the placenta for fetal nutrition, oxygenation, and maturation. The pregnant woman’s physiology is definitely not separate from that of the fetus. The fetus is *physiologically* a part of the pregnant woman.

One of the most unexpected findings has been that the conceptus and mother share immunological regulation, and that these regulatory properties are critical for both implantation and parturition. The beginning and ending of labor may be controlled by the interactions between the embryo, uterus, and immune system. The implanting embryo has proteins from the father’s portion of the genome, and the pregnant woman’s immune system would be expected to recognize and destroy such cells. However, this is not what happens.<sup>135</sup> Instead, mammals have evolved a mechanism for turning foes into friends, allowing the embryo to become a part of the woman’s body rather than being destroyed.<sup>136</sup>

Recent studies have shown that the implanting embryo actually initiates an inflammatory reaction, characteristic of an antagonistic immune response. This seems a dangerous strategy. Inflammation has classically been seen as one of the greatest threats to normal pregnancy, causing preterm labor and the death of the fetus.<sup>137</sup> One of the properties of such a reaction is that immune cells release a class of proteins (cytokines) that destroy tissues and their extracellular matrices.<sup>138</sup> Although this destruction might help the lymphocytes find and eliminate bacteria and viruses, it also breaks down normal tissues, causing the pain and swelling characteristic of inflammatory responses.

However, new findings<sup>139,140</sup> have shown that such inflammation is critical in both the implantation of the embryo into the uterus and the eventual expulsion (parturition) of the embryo from the uterus during labor. Upon implanting, the blastocyst initiates an inflammatory response. However, the uterine decidual cells, primed by progesterone, produce cytokines that modify the development of NK cells, a class of lymphocyte that orchestrates inflammation. The modified NK cells block the recruitment of macrophages into the uterus. This prevents the inflammation from spreading and prevents the immune responses that would kill the embryonic cells. However, the modified inflammatory response does cause a softening of the uterine tissue, making it more receptive to receiving the embryo. Moreover, placental estrogen and progesterone contribute to the maternal tolerance of the fetus by modulating the proliferation and cytokine secretion of cytotoxic T cells while enhancing the suppressive function of suppressive, regulatory T

cells.<sup>141-143</sup> In this way, the embryo helps control the uterine immune response.

At the end of gestation, uterine inflammation and cooperation with the fetus again becomes important. Here, the fetal lungs may also be critical in ending pregnancy.<sup>144,145</sup> Mendelson and colleagues<sup>146,147</sup> showed that several lung surfactants enter the amnion and activate macrophages in the amniotic fluid. These macrophages migrate from the amnion into the uterine muscle, where they secrete immune cytokine proteins such as interleukin-1 $\beta$  that initiate the contractions of labor. Studies have shown that mice deficient in surfactant proteins have a significant delay in the onset of labor, whereas surfactant-stimulated macrophages injected into the uteri of female mice induce early labor.<sup>148</sup> Thus, one of the critical signals initiating birth is given only when the lungs have matured to the point where a newborn can take its first breath, and this signal may be transmitted to the mother via her immune system. Working together, the fetus and the uterus use the maternal immune system to both begin and end pregnancy. The embryo and mother are *immunologically* linked as well.

Thus, the fetus and uterus are linked anatomically, physiologically, and immunologically. Moreover, as mentioned earlier, when the first breath is taken, the heart anatomy is altered, and respiratory circulation is shunted from the placenta to the lungs. So birth is not just a transit of a few inches from womb to the outside world, but it is a perilous event where an independent biological life can be said to begin.

## CONCLUSION

“Ignoring the historical backdrop of eugenics debates dooms scientists to a future as co-conspirators in the production of inequality.”

-Banu Subramanian<sup>149</sup>

Public discussions of when science says independent human life or personhood begins have little or nothing to do with actual science. Rather, what is represented as science is a misogynist pseudo-embryology based on nonscientific myths. The masculine legend of the heroic sperm, supported by the notions of genomic ensoulment and an autonomous seedlike fetus, has promoted fertilization as the time when a full human life begins. This pseudo-embryology supplants the female story of birth as when a biologically individualized human life starts. This ideology also subverts a discussion of the reciprocity that science finds in human reproduction. There is competition and death among cells (which is common to many areas of development<sup>150</sup>), but modern biology also sees a fuller story of reciprocal encounters, interactions, and support.

These myth-laden distortions have had severe political implications, and the debates on abortion and personhood are just two of the more prominent. We argue here that the belief that scientists have shown that fertilization is when personhood begins is based on three discredited myths: the sperm as hero, the genome as soul, and the uterus

as nutritive vessel. These myths mutually support one another such that they generate a cogent belief system that resists new scientific data. In their recent analysis of scientific communication, Leng and Leng<sup>151</sup> conclude, “Simple stories that create a coherent explanatory chain and which are given salience by emotional cues in the telling of them are those most easily remembered and which will be most commonly repeated.” Such stories, they say, preclude mentioning contrary evidence. Such cogent belief systems can help form normative science, but when they are left unchecked by other scientists, and when they conform well into social mores, they become the bases for conspiracy theories and pseudoscience.<sup>152</sup> When they are propagated as science, they do great harm. This corruption occurred earlier in the past century to generate eugenics and racial science.<sup>127,153</sup>

Scientists have identified more than one possible point at which an individual life, personhood, with its own identity, and defined in various ways, begins. There is no consensus among biologists as to when an independent human life begins. Those people who invoke the scientific community to justify the idea that fertilization is the unequivocal moment of independent identity for the human embryo are expressing mythological and political ideas, not contemporary scientific facts. These mythologies have deep and powerful roots, and they are hard to leave behind. We often look back on how eugenics distorted American politics a century ago, how women were being sterilized in the name of science, and we congratulate ourselves, thinking that such distortions could not happen again. They have.

These mythologies are being enacted into laws. Having overturned the Roe v Wade decision that gave women federal rights to have an abortion,<sup>154</sup> anti-abortion activists are striving for a more absolute goal that lay behind their legal maneuvers: to grant the embryo rights as a person.<sup>155</sup> Such “fetal personhood laws” would make abortion equivalent to murder and eliminate exceptions that allow abortions in medical emergencies. In Indiana, where the legislature recently banned abortions starting at conception, some legislators were not satisfied, because it allowed exceptions for rape and incest.<sup>156</sup> Said one congressman, “This bill justifies the wicked, those murdering babies, and punishes the righteous, the preborn human being.”<sup>157</sup> The governor of Georgia has proposed a similar zygotic rights bill declaring the “paramount right to life of all human beings as persons at any stage of development from fertilization to natural death.” At least 11 states as well as the US House of Representatives will be discussing the enactment of such laws this year.<sup>158</sup>

The state-based sterilization laws and national Immigration Act of 1924 were passed through the combination of racial myths fueled by false science. Passing these laws was seen as the moral duty of white citizens, and this led to the sterilization of over 700,000 US citizens, and they became the basis for the racial extermination laws of Nazi Germany.<sup>159-161</sup> The fetal personhood crusade is a mix of myth, misogyny, and politics. Science should not be a part of it. However, by stating that embryologists have all concluded that personhood begins at fertilization, politicians are using pseudoscience to justify a political and social movements, just as surely as eugenics was to justify the racial claims of a century ago.

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