

## Why Not Artificial Wombs?

*Christine Rosen*

In 1924, the British scientist J.B.S. Haldane coined the term “ectogenesis” to describe how human pregnancy would one day give way to artificial wombs. “It was in 1951 that Dupont and Schwarz produced the first ectogenetic child,” Haldane wrote, imagining how an earnest college student of the future would describe the phenomenon. “Now that the technique is fully developed, we can take an ovary from a woman, and keep it growing in a suitable fluid for as long as twenty years, producing a fresh ovum each month, of which 90 percent can be fertilized, and the embryos grown successfully for nine months, and then brought out into the air.” By the year 2074, Haldane imagined, ectogenesis had become a popular technique—with “less than 30 percent of children... now born of woman.” Writing at a time when debates over contraception and eugenics raged on both sides of the Atlantic, his prediction was an understandable outgrowth of these new efforts to control fertility. “Had it not been for ectogenesis,” Haldane prophesied, “there can be little doubt that civilization would have collapsed within a measurable time owing to the greater fertility of the less desirable members of the population in almost all countries.”

Today, we have inched slightly—but only slightly—closer to perfecting the technology that would realize Haldane’s vision, albeit for reasons other than the eugenic improvement of the race. A small knot of scientists in the United States and Japan are experimenting with both live animals and human cells to mimic the functioning of the womb. And while their work is in its early stages, it is worth exploring the scientific prospects and ethical implications of research on artificial wombs.

Haldane’s chosen title—*Daedalus*—is perhaps telling. In Greek mythology, Daedalus, “the cunning worker,” was an ingenious practitioner of the mechanical arts, a figure whose inventions proved, at best, ambiguous contributions to humanity. His most famous invention—wings crafted from bird feathers, wax, and string, built to escape with his son Icarus from the clutches of King Minos—became the tool of his son’s destruction, when “the boy, exulting in his career, began to leave the guidance of his companion and soar upward as if to reach heaven.” The hot sun promptly melted the wax wings, Icarus plunged to his death, and Daedalus was left “bitterly lamenting his own arts.”

Haldane chose a very different side of Daedalus to praise in his essay, however. He hailed Daedalus as “the first modern man,” because “he was the first to

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demonstrate that the scientific worker is not concerned with gods” and not haunted by old taboos. The doomed flight of Icarus was, after all, also a triumph of engineering. The same might be said of artificial wombs. With scientists impatient to extend research on embryos at the earliest stages of life, and researchers at the other end of pregnancy constantly pushing back viability for prematurely-born infants, at some point these two forces will likely meet. If they do, the result will be a new era in human procreation: a world in which children are created in the laboratory, gestated in some artificial womb-like environment, and brought “to term” without ever really being “born.”

### **Building Better Wombs**

Efforts to mimic nature’s reproductive powers are nothing new. As long ago as the fifteenth century, breeders of Arabian horses practiced crude forms of artificial insemination to ensure the continuation of the best of the breed. Early students of anatomy in the sixteenth and seventeenth centuries, such as Andres Vesalius, Nicolaas Hartsoeker, and Marcello Malpighi, examined chicken eggs, animals, and, when they could, the bodies of deceased pregnant women to determine how reproduction and gestation worked.

Closer to our own time, scientists attempted, with little success, to create artificial wombs for lambs in the 1950s and 1960s. The pursuit of ectogenesis languished, with the exception of sporadic debates in the pages of journals such as *Utopian Studies*, until the 1980s. It was then that researchers in Tokyo began achieving increasingly promising results in their artificial womb experiments with goats. Led by Dr. Yoshinori Kuwabara of Juntendo University, this work resulted, in 1997, in the announcement that a 17-week-old goat fetus, removed from its mother’s uterus, had survived for three weeks in an artificial womb. The technique, called extrauterine fetal incubation, involved placing the goat fetus in a plastic container of warmed, amniotic-like fluid, where it was supplied with nutrients through a tube inserted in its umbilical cord.

At the same time, developments in interspecies gestation in animals continue to whittle away at the barriers to reproduction between species, raising the possibility of gestating or partially gestating a human child in a non-human animal uterus. In 2002, researchers at the Institute of Zoology at the Chinese Academy of Sciences reported the creation of 2,300 hybrid panda-rabbit embryos (produced by inserting panda DNA into enucleated rabbit eggs) and their implantation into rabbit wombs. No pregnancies resulted from this experiment, but later attempts using panda-rabbit clones implanted in cats yielded a pregnancy. In similar experiments, scientists in Spain have produced live ibex kids from ibex embryos implanted and gestated in domestic goats. Researchers at the Department of Animal Science at the University of California, Davis, have been studying interspecies and hybrid pregnancies in sheep and goats. And

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researchers at Iowa State University have created “interspecies chimeric calves” in an effort to help preserve certain endangered species.

Speculation about using such interspecies techniques in humans is already a regular feature of much scientific commentary, at least among the most vigorous enthusiasts and critics of our new reproductive powers. “Rather than expending all scientific talent and resources developing artificial wombs,” *Reason* science correspondent Ronald Bailey wrote recently, “I suspect that it will be much easier and cheaper to establish pregnancies with human embryos in other mammals, like cows and horses, than it will be to achieve the same thing using artificial uteruses.” This interspecies prospect was recently the subject of discussion by the President’s Council on Bioethics, which is considering recommending a ban on the implantation of human embryos into any non-human animal uterus.

Research in three other areas may also contribute to the creation of artificial wombs: studies of amniotic fluid and the possibilities of liquid ventilation; efforts to mimic the lining of the womb using human uterine cells and a cocktail of hormones; and the many physicians and scientists involved in the field of neonatology, who are constantly pushing back the boundary of viability in their work with prematurely-born babies.

Working at the embryonic stages of life, Dr. Hung-Ching Liu of the Weill Medical College at Cornell University has engineered endometrial tissue in the laboratory by taking cells from a woman’s endometrium and prompting them to grow on a biodegradable scaffolding shaped like a human uterus. When Liu introduced an embryo to the artificial uterine lining, it successfully implanted. “The embryo grows very happily and very healthy,” she noted during the American Society for Reproductive Medicine conference in 2001. “The characteristic of this embryo development is very similar to that in vivo.” In these early experiments, she allowed the embryo to grow for six days. But Liu told reporters that, in future experiments, she has every intention of allowing embryos to develop further and longer.

Advances in neonatology may also lay the groundwork for the eventual creation of artificial wombs. It is already possible to save a child born during the early part of the second trimester of pregnancy and weighing only two pounds. Research on liquid ventilation, particularly that conducted by Dr. Thomas Schaffer at Temple University, offers hope for treating premature infants by mimicking the fluid found in the lungs in utero. Isolettes—the technologically sophisticated incubators that fill the neonatal intensive care units of major hospitals—are, one might say, a cruder version of an artificial womb.

The question is whether these different avenues of research—at the beginning of pregnancy and the end of pregnancy—will one day converge. “I’ve talked to researchers who are doing research on partial ectogenesis—interventions for premature births, mainly—and I’ve talked to in vitro fertilization researchers who

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are trying to extend the period of time an embryo can live outside the womb,” says Scott Gelfand, Director of the Ethics Center at the University of Oklahoma, Tulsa, who organized a conference on artificial wombs in 2002. “Put the two together and eventually we’re going to be able to do this.” Of course, many scientific and biological hurdles remain, and physicians who work with assisted reproductive technologies are hesitant to predict the future. “The uterus is a complex organism,” says Dr. David Adamson, Director of Fertility Physicians of Northern California and past president of the Society for Assisted Reproductive Technology. “There are still issues related to immunology and cardiovascular development that are extremely complicated and not very well understood. In terms of putting together all of these and having a clinically successful artificial womb,” he says, “my personal perspective is that it is decades away.”

The boldest claims come from those who are actually engaged in the research. After his successful artificial womb experiments in goats in 1997, Dr. Kuwabara told reporters, “If I have the time and money for experiments, maybe within ten years we will have made the move from animal to humans.” Similarly, during an interview at the American Society for Reproductive Medicine Conference in 2001, Dr. Liu didn’t exactly demur when asked about the implications of her research. “Is it ... science fiction to say maybe in the far future you could have a real breathing embryo and have a child in the laboratory?” the interviewer asked. “That’s my final goal,” said Dr. Liu. “I call it an artificial uterus. I want to see whether I can develop an actual external device with this endometrium cell and then probably with a computer system simulate the feed in medium, feed out medium... and also have a chip controlling the hormone level.” While conceding that such baby-incubating technology lies in the future, Dr. Liu said, “I believe this can be achieved, we could possibly have an artificial uterus so then you could grow a baby to term.”

Ethicists, as is their wont, appear willing, if perhaps less able, to make more specific forecasts. Speaking to a *New York Times* reporter in 1996, bioethicist Arthur Caplan thought sixty years was a foreseeable horizon for functional artificial wombs. “It’s technologically inevitable. Demand is hard to predict, but I’ll say significant.” Asked about the avalanche of moral issues such a technology could pose, Caplan answered cheekily, if a bit chillingly, “the future is rosy for bioethicists.”

Such speculation is compounded by the wacky contributions of groups such as the clone-happy Raelians, who issued a press release in February 2003 declaring their intention to create an artificial womb called BABYTRON to nurture their future faithful. Also on the fringes, or forefront, depending on one’s sensibility, is China. According to the *Far Eastern Review*, scientists at the Chinese Academy of Medical Sciences have undertaken experiments to implant artificial wombs in men’s abdomens. “Potential male moms are required to conform to the

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following requirements,” reported *China Today*. “A strong desire to have a child of their own genes and hereditary features; payment of a 200,000 yuan (\$24,000) surgery fee; being possessed of a courageous spirit, and trust in science.”

So how close are we to creating fully functioning artificial wombs, capable of gestating a human child from the embryonic stage to the fetal stage to a state of viability? It would be a mistake to be seduced by the hype. BABYTRON machines and “motherless births” are not on the immediate horizon. But simply to ignore the prospect—including the incremental advances being made in this direction at leading academic institutions—would be short-sighted. And simply to ask the question—Why not artificial wombs?—is to consider how far we have gone, at least in principle, toward accepting a world in which mothers become dispensable, and normal childbirth becomes a choice, perhaps even a primitive one.

### **The Meaning of Motherhood**

Artificial wombs are just the kind of technological prospect that radical ethicists love to celebrate. In 1985, philosopher Peter Singer gave them a ringing endorsement: “I think women will be helped, rather than harmed, by the development of a technology that makes it possible for them to have children without being pregnant,” he said. Singer’s vision echoed that of feminist theorist Shulamith Firestone, who made a similar argument in 1970 in *The Dialectic of Sex*. Once the “freeing of women from the tyranny of their reproductive biology” occurred, she said, they could finally reach full equality with men. Viewed this way, artificial wombs are merely another step in the ongoing advance of human reproductive technologies and women’s social equality. They would both expand the range of reproductive choices and make the differences between men and women matters of technological convention rather than biological nature.

Proponents of artificial wombs also point to what they see as the potential medical benefits of this technology: helping women who have suffered multiple miscarriages due to problems with embryo implantation, or women who have had hysterectomies due to uterine cancer. For women with multiple pregnancies, artificial wombs could provide temporary quarters for one or two fetuses toward the end of gestation, when a woman’s womb becomes more crowded and the risk of complications to herself and her children are greater. And for those unable to carry their own child, artificial wombs would provide an alternative to surrogacy. “The same concerns about women—that surrogacy reifies them, that these arrangements take psychological or economic advantage of them—that whole range of concerns is gone when you talk about artificial wombs,” says Roger B. Dworkin, a professor at Indiana State University School of Law in Bloomington. Other concerns—such as turning procreation into manufacture or severing the biological connection between mothers and newborns—are viewed as unlikely. “Presumably babies would be created because someone wanted a baby. To imag-

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ine some hideous scenario of millions of babies created artificially for some specific purpose strikes me as unrealistic.”

But many ethicists are not so sure. “I think artificial wombs could lead to a commodification of the whole process of pregnancy,” says Rosemarie Tong, a professor at the University of North Carolina, Charlotte, and a leading scholar in feminist bioethics. “To the extent that we externalize an experience like pregnancy, it may lead to a view of the growing child as a ‘thing.’” The further we erode the mystery of the development of human life, the more appealing it becomes to think about improving upon it, or demanding greater control over it. Even given developments in fetal surgery, the human womb still insists that we not breach its protections too often. But with artificial wombs, the transparency of the technology itself would invite greater intervention.

At stake in this debate is the very meaning of human pregnancy: the meaning of the mother-child relationship, the nature of the female body, and the significance of being born, not “made.” Let’s say, for example, that scientists perfect the artificial womb to the point where it becomes a “healthier” environment than the old-fashioned human version. Artificial wombs, after all, wouldn’t be threatened by irresponsible introductions of alcohol or illegal drugs. They could have precisely regulated sources of temperature and nutrition and ongoing monitoring by expert technicians in incubation clinics. Like genetic testing of unborn fetuses, which is fast becoming a medical norm rather than a choice, people might begin to ask: Why take the risk of gestating my child in an old-fashioned womb? With an eye to avoiding costs and complications, insurance companies might begin to insist that we don’t. (Imagine “expectant mothers” stopping by the incubation clinic once a week to check up on their “unborn” child.)

In the near term, most women would almost certainly gestate their children the old-fashioned way, even if they had the choice. “Relatively few people, with tons of money, who are unusual, would use artificial wombs,” says Tong. But even the option of artificial wombs might change the way we view pregnancy, and perhaps the way we view women. Feminist critics of science, particularly those who embrace an “essentialist” view of women, have long claimed that artificial reproductive technologies threaten women’s social status. Australian sociologist Robyn Rowland has argued that the creation of artificial wombs would spell the end of women’s innate power. “We may find ourselves without a product of any kind with which to bargain,” she writes. “We have to ask, if that last power is taken and controlled by men, what role is envisaged for women in the new world? Will women become obsolete?” Rowland and other feminist critics are hardly shrinking violets; they called their 1984 conference on the subject “The Death of the Female.” They view the medical establishment as irredeemably male—a monolithic, misogynistic institution that views women who are not pregnant as, literally, idle machines.

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More thoughtful feminist critics note that even without the possibility of manipulation by the medical establishment, artificial wombs would create serious disruptions in our relationships with our children. “It would weaken the mother-child bond,” says Tong. “Indeed, I think it would weaken the bonds between parents and children in general. On the whole, I think the physicality and embodied nature of pregnancy is a real and material way for one generation to connect to the next... Without that rootedness in the body, relationships between the generations become more abstract, less feeling-filled.”

It is this prospect—children without mothers, babies molded in machines—which chills the blood when reading of children being “decanted” in Aldous Huxley’s *Brave New World*. How would these gestational foundlings differ from children developed in human wombs? Are there things about the womb that we simply can’t replicate but that might, in fact, be integral to healthy human development? To be “born of woman” is not merely to be born using a certain technique, a means that is suitable today but perhaps will be superseded in the future by our own ingenuity. This is a point persuasively made by Charles Krauthammer at the October 2003 meeting of the President’s Council on Bioethics:

Why do we want the embryo to be housed in its mother? One of the reasons is that it creates an innate connection between the child and the mother, and the mother becomes uniquely protective and attached. That’s human nature. It’s even animal nature as well... And it’s not the mixing or the “yucking” that’s at issue here. It may be severing the connection between the child and the mother, which is a way of protecting that child by giving him a belonginghood to someone who will care. Once you put him in an animal, which is a thing for these purposes, or a machine, which might happen in the future, you create a completely atomized and defenseless creature, and that opens the way to all kinds of tyrannies, social control, and lack of autonomy, which we would not want.

Even Haldane obliquely acknowledged the reality of this mother-child bond, when he predicted, in *Daedalus*, that despite the widespread use of ectogenesis, women would be injected with a hormone to prompt lactation so that they could still breastfeed their artificially-gestated children.

To be sure, motherhood has already changed significantly due to scientific and social developments. We rightly praise motherhood without biological links in the case of adoption, and we largely accept motherhood with biological links but without pregnancy in the case of surrogacy. Single-motherhood is also increasing, mostly because of divorce, but also because of single women using artificial insemination. In this context, artificial wombs could be viewed as simply a continuation and expansion of the new idea of the family. It enshrines technologically a current cultural reality: the erosion of the belief that mothers and fathers are unique and thus different, not interchangeable.

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## Life After Birth

Perhaps it is premature to consider the ethical implications of artificial wombs, with the technology for achieving them likely far off in the future. And yet, the prospect of ectogenesis raises questions of more immediate significance, and thinking about this future prospect compels us to examine (or re-examine) some current practices. “If reproduction is at once completely separated from sexual love,” Haldane wrote, “mankind will be free in an altogether new sense.” But free to do what? In just the last few years, we’ve used this freedom to create mixed-sex, “she-male” embryos. We’ve harvested the undeveloped ovaries of aborted fetuses, and thus opened the door to producing children with aborted fetuses as biological mothers. We’ve produced female oocytes from male-derived embryonic stem cells, and thus laid the groundwork for single-sex procreation. In this context, ectogenesis seems more like a culmination of present trends than a radical departure; it seems like yet another sign, or signpost, of our inability to accept limits on the use of reproductive technologies.

In *Brave New World Revisited*, Aldous Huxley noted that a narrow-minded focus on order and control “can make tyrants out of those who merely aspire to clean up a mess. The beauty of tidiness is used as a justification for despotism.” The point of Huxley’s original tale, after all, was to remind us of the human impulse not merely to mimic nature, but to improve upon it. His hatchery moved “out of the realm of mere slavish imitation of nature into the much more interesting world of human intervention.” The inexorable desire to update, improve, and perfect, he warned, can have unforeseen consequences.

In this spirit, perhaps we shouldn’t treat the human womb like just another organ to be replicated and improved upon. When a Seattle dentist named Barney Clark received the first artificial human heart in 1982, concerns about how artificial organs might change us were largely lost in the avalanche of praise for this inspiring technical advance. Like the Tin Man in the Wizard of Oz, Clark had finally received a heart (which, sadly, allowed him to survive for only 112 days before his body rejected the device and he died). This feel-good narrative even came complete with an Oz-like figure, Dr. Willem Kolff, a Dutch-born scientist who invented the first kidney dialysis machine (an external artificial kidney, if you will), who helped design that first artificial heart, and who is currently hard at work creating an artificial lung.

The idea of Dorothy clicking her heels three times and wishing for an artificial womb is somehow more unsettling; the metaphor fails. Why? Perhaps some things are so ineffable that they shouldn’t be artificially reproduced. When synthesized music hit the airwaves in the 1970s, its promoters claimed that now, in the privacy of your own home and for the price of a tiny electronic keyboard, the sounds of the New York Philharmonic would be at your fingertips—to be made,

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not just listened to. The machine promised perfect imitations of the pitch, timbre, and volume of the original instruments. But as is all too evident if you turn on the radio, synthesized music was used most effectively by pop musicians who preferred the electronic mimic of forty violins to the real thing, and by “synthesized music composers” who produce crimes against symphonies with titles such as “Romantique Fantastique.” This is a far cry from the elevated predictions of synthesized music’s early devotees, including men such as Milton Babbitt, who waxed enthusiastic about “the notion of having complete control over one’s composition, of being complete master of all you survey... to hear one’s music as it was conceived.”

Of course, synthesized music is hardly the same thing as an artificial womb. But the parallel is at least suggestive. In both cases, it is not the product alone that matters, precisely because the end we seek (music, children) is more than just a product. The process of creation—the living birth and the live musician—actually matters. Even the phrase “artificial womb” appears at odds with itself: “artificial” conjures images of chemical sweeteners, synthetic fabrics, second-best imitations, while “womb” still retains its mystery and its gravity.

Artificial wombs spur us, like Icarus, to test the extreme and more dangerous limits of our technical powers. “Maybe we are not yet ready to use this technology in a responsible way,” says Gelfand. “If you don’t give a child matches, he won’t start a fire.” Eighty years earlier, Haldane offered a similar metaphor: “Man armed with science is like a baby with a box of matches.” Although billed as yet another future reproductive option, artificial wombs have the potential to change us in ways still difficult to fully imagine. Haldane argued that science held possibilities if “mankind can adjust its morality to its powers.” But why should our powers remake our morality? And why do we fashion ourselves wise enough to begin a new era in human life—“life after birth”—without wreaking great havoc? Of course, the greatest tragedy may be the very lack of havoc: A society of situational moralists, their morality adjusted to suit their powers, might be happier, healthier, and less troubled by ethical dilemmas. But it would not be human in the same way it once was.

### **The Mystery of the Womb**

There has always been an incalculable mystery surrounding the womb, as religion and folk wisdom attest. “As thou knowest not what is the way of the spirit, nor how the bones do grow in the womb of her that is with child: even so thou knowest not the works of God who maketh all,” says Ecclesiastes. In the Hebrew Bible, interventions in the womb were considered to be solely the province of God, not man. In the story of Rachel and Jacob, when the barren Rachel says, “Give me children, or else I die,” Jacob responds in anger, saying “Am I in God’s stead, who hath withheld from thee the fruit of the womb?” For centuries, folk

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tales warned pregnant women against walking in graveyards, looking at deformed people, witnessing a solar eclipse, or even strolling around after dark, lest they damage the developing child.

Our feelings of awe and curiosity about the womb are a reaction both to its physiological function and its potent status as a symbol of fertility, procreation, and the continuation of the species. It is not quite an organ, although it can be donated and transplanted; and it is more mysterious than the heart or the lungs, which both men and women share. It is freighted with meaning because it is the site, or the potential site, of such a fundamental and in many ways still deeply mysterious thing—the emergence and development of a new human life.

In an essay written just before he died, the philosopher Hans Jonas observed that “natality,” as he called it, “is as essential an attribute of the human condition as is mortality. It denotes the fact that we all have been born, which means that each of us had a beginning when others already had long been there, and it ensures that there will always be such that see the world for the first time, see things with new eyes, wonder where others are dulled by habit, start out from where they had arrived.” In the end, artificial wombs are different from current technologies like IVF and modern arrangements like surrogacy, because they represent the final severing of reproduction from the human body. There is something about being born of a human being—rather than a cow or an incubator—that fundamentally makes us human. Whether it is the sound of a human voice, the beating of a human heart, the temperature and rhythms of the human body, or some combination of all of these things that makes it so, it is difficult to imagine that science will ever find a way to truly mimic them. We should remember this truth as we expand the reach of our powers over the very origins of human life, lest we give birth to a technology we will live to regret.