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ARTIFICIAL WOMB: A SHORT HISTORY

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ABSTRACT

The idea of artificial wombs began to be seriously discussed in the West in Britain after WWI, inspired by modern feminism and the invention of neonatal incubators. J. B. S. Haldane's imagined future use of artificial wombs in his essay *Daedalus, or, Science and the Future* inspired debate among his contemporaries for a decade, including Aldous Huxley who indelibly cast the technology as dystopian. After WWII bioutopian ideas like artificial wombs were associated with fascism, although socialist feminists briefly renewed the debate over the liberatory potential of artificial wombs in the 1970s. Recent innovations in neonatal intensive care have again generated discussion of the ethical and political impacts of artificial wombs. Again, artificial wombs are seen by some as a way to expand reproductive freedom and gender equality, while critics worry they might have negative impacts on women and abortion access.

KEYWORDS: artificial womb; J.B.S. Haldane; Aldous Huxley; B. Russell; J. D. Bernal; in vitro fertilization

1. ARTIFICIAL WOMBS IN SCIENCE FICTION

There are mythological antecedents to the contemporary idea of the artificial womb. In the myths associated with the Indian Mahabharata, for instance, there is the story of Queen Gandhara causing a miscarriage in her sister-in-law, Kunthi, out of jealousy. Kunthi planted a hundred pieces of her shattered fetus in one hundred jars of ghee, and these became the hundred Kaurava princes (Wei 2017). Zeus gestated both Athena and Dionysus in his own body. However, the consequential discussion of artificial wombs began in the 20th century in England.

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1.1. J.B.S. Haldane to Brave New World

The first major, modern discussion of artificial wombs began in 1923 in a talk by biologist J. B. S. Haldane to the Cambridge University Heretics Club. The talk was shortly published as *Daedalus, or, Science and the Future* (J. B. S. Haldane 1923), the first of over 150 short books published by Kegan Paul over the next eight years as the "To-day and To-Morrow" series, all debating radical political and scientific ideas. Writing from the perspective of a utopian 21st century, Haldane imagined (among many radical changes) that scientists would succeed in raising embryos in a "suitable fluid," and artificial wombs or "ectogenesis" would become the dominant way children would be created, enabling eugenic improvements.

> As we know ectogenesis is now universal, and in this country, less than 30 percent of children are now born of woman…The small proportion of men and women who are selected as ancestors for the next generation are so undoubtedly superior to the average that the advance in each generation in any single respect, from the increased output of first-class music to the decreased convictions for theft, is very startling. Had it not been for ectogenesis there can be little doubt that civilisation would have collapsed within a measurable time owing to the greater fertility of the less desirable members of the population in almost all countries. (J. B. S. Haldane 1923)

Most of Haldane's friends and interlocutors rejected ectogenesis, even if they shared his techno-optimism, criticism of the nuclear family, and eugenic concerns (Squier 1995). In 1927 for instance Haldane's wife, Charlotte Haldane, published the science fiction dystopia *Man's World* (C. Haldane 1926), depicting a future ruled by a male, white supremacist scientist caste that used ectogenesis while sterilizing unfit women.

J.B.S. Haldane went on to become a Marxist and reject the eugenics movement, but he and his wife hosted a popular salon for radical and controversial intellectuals in the 1930s in which ideas such as artificial wombs were debated. In his To-day and To-morrow contribution *Lysistrata, or Woman's Future and Future Women* (Ludovici 1925) Nietzsche scholar Anthony Ludovici devoted pages to the idea that artificial wombs would be part of the pernicious feminist agenda that would destroy Western civilization. Ludovici imagined women making men superfluous with artificial insemination, banning natural reproduction, and using cows, donkeys, and incubators to gestate their daughters and a few emasculated sons. Ludovici's profoundly misogynistic view would be echoed in August Anson's 1938 novel *When Woman Reigns* which depicted ectogenesis as part of a 26th-century matriarchal world.

The Haldane circle also included Bertrand and Dora Russell, both socialists and feminists. In her 1925 rejoinder to Ludovici, *Hypatia, or Woman*

and Knowledge (Russell 1925), Dora defended feminism and the liberatory importance of birth control and ectogenesis. Likewise, Dora Russell's collaborator in working to legalize birth control, sex education, homosexuality, and divorce, the Australian sexologist Norman Haire, contributed to the debate with *Hymen, or the Future of Marriage* (Haire 1927) which mused on the possibility of gestating humans in modified animals (Ferreira 2013). In her 1929 *Halcyon, or the Future of Monogamy*, however, feminist and pacifist Vera Brittain rejected ectogenesis for its likely erosive effect on vital parent-child bonding (Brittain 1929).

Irish Marxist and scientist J. D. Bernal is best known for his seminal 1929 essay *The World, the Flesh & the Devil: An Enquiry into the Future of the Three Enemies of the Rational Soul* (Bernal 1929) which first proposed cyborgs as the ideal form that space colonists would take in a socialist future. But Bernal was also responding to *Daedalus* and the To-day and To-morrow essays, and he opined that lives would start "as Mr. J. B. S. Haldane so convincingly predicts, in an ectogenetic factory." Bernal worried however that artificial wombs and cyborgization could divide an enhanced scientist caste from the unenhanced, obliging them to migrate to space, unless the scientist caste convinced the rest of society to join them, or achieved supremacy in a Soviet regime (Schwartz 2019).

The brothers Aldous and Julian Huxley were also members of the Haldane circle. Julian Huxley, a socialist and scientist, would coin the term "transhumanism" in the 1950s in his appeal to synthesize a new humanism for a future humanity transformed by emerging technologies. Aldous, on the other hand, was more horrified by the Haldanian utopians, and he made artificial wombs central to his 1932 dystopian classic *Brave New World* (Huxley 2004). Aldous depicted ectogenesis as the means to eliminate parent-child relationships and intentionally brain damage infants (in a "Social Predestination Room") so that they would be happy as "deltas" and "gammas" (Huxley 2004).

1.2. 1970s Radical Feminism and Science Fiction

After World War Two all political quarters rejected eugenics and bio-utopian musings for their associations with fascism, and "*Brave New World"* became shorthand for techno-authoritarianism. For decades artificial wombs returned to the pages of science fiction. For instance, Frank Herbert, author of the *Dune* saga, introduced a very dystopian take on artificial wombs in his 1969 *Dune Messiah* (Herbert 1969). In Herbert's world-building the Tleilaxu planet was controlled by men able to transfer their consciousness from clone to clone. To grow their clones they secretly lobotomized all their women and called them "Axolotl Tanks." His insectoid humans in *Hellstrom's Hive* also used lobotomized women as "procreative stumps" (Herbert 1973). While

Herbert was not a feminist by contemporary standards, his association of artificial wombs with lobotomized women reflected a persistent feminist critique of the artificial womb, that it would contribute to, or be the result of, women's degradation and enslavement.

The most forceful case for the utopian potential of artificial wombs was made in 1970 by socialist-feminist writer Shulamith Firestone in her book *The Dialectic of Sex: The Case for Feminist Revolution* (Firestone 1970). Combining Marxist historical materialism with radical feminism, Firestone argued that dependence on women for making children ("social reproduction") and women's vulnerability during multiple pregnancies, was the material basis for women's subjugation. Social reform would be of only limited benefit until women were liberated from pregnancy by the artificial womb.

Feminist science fiction author Marge Piercy also took up the case for artificial wombs in her 1976 novel *Woman on the Edge of Time* (Piercy 1976). Piercy depicted a future socialist-feminist utopia in which most babies were incubated instead of birthed. While artificial wombs have remained unpopular and rare in both radical politics and science fiction, the idea continues to emerge in both positive and negative contexts (Strumfels 2015). "Uterine replicators" are used by women, and a society of gay men, in the Miles Vorkosigan novels by Lois McMaster Bujold (Bujold 1986a; 1986b; 2002; 1991). Dystopian examples include the gestation tanks in the Matrix films and, for clones, in the Star Wars universe. Two contemporary, award-winning science fiction authors, both women, have made artificial wombs the normative standard in their universes, Yoon Ha Lee in her *Machineries of Empire* series and Arkady Martine in her *Teixcalaan* series (TV Tropes 2021).

2. Progress towards artificial wombs

In the 1960s technological progress on artificial insemination and neonatal intensive care began to make artificial wombs more than political and literary speculation.

2.1. In-vitro fertilization and gestation

At the embryonic stage, in-vitro fertilization has been successful since the 1970s and globally millions of people have spent their first days in test tubes. Embryos can develop ex-utero for at least two weeks (Shahbazi et al. 2016), although standard practice in in-vitro fertilization is to either implant or freeze blastocysts by the sixth day when they contain around one hundred cells that have begun differentiating into different tissues. After the first week, without more progress towards artificial wombs, the success rate for

subsequent implantation drops quickly. Once embryos are frozen they can be stored indefinitely. Research on growing embryos in-vitro for more than two weeks is forbidden in many countries (Chan 2018; Matthews and Moralí 2020).

2.2. Neonatal Intensive Care Units (NICUs)

The first known incubator for preterm infants was developed in France in 1880 when obstetrician Etienne Tarnier placed infants in a wooden box with a hot water bottle. Incubators for infants were subsequently exhibited at fairs in Germany, the United States, and Great Britain to much acclaim, and probably contributed to stimulating Haldane's imagination in 1923 (Ferreira 2017). But it was not until after World War Two that special hospital units for newborns were first built in Britain and the United States. Hospitals generally did not attempt to rescue infants born before 32 weeks of gestation, because even if they survived they had many disabilities.

Specialized incubators with controlled oxygen and temperature were introduced in the 1960s. By the 1970s births as early as 24 weeks were being treated in "neonatal intensive care units" or NICUs. Although progress has been made in replicating some conditions of the uterus, premature births still suffer from a very high incidence of death and disabilities due largely to underdeveloped lungs being exposed to air or mechanical ventilation. Only one out of five infants born at 23 weeks or younger (in the United States) survive, and most of those have severe life-long disabilities (Prasad 2017).

Two innovations that have improved NICU survival and lowered the disability rate are artificial surfactant and extracorporeal membrane oxygenation (ECMO). Infants born before 34 weeks of gestation do not yet produce surfactant to protect their lungs from collapsing when exposed to air. Synthetic surfactant, introduced in the 1980s, has dramatically reduced the mortality and morbidity rate of preterm infants suffering from respiratory distress from 100% to less than 10% (Mandile 2017).

ECMO is a procedure implemented in NICUs in the 1980s which removes blood from an infant's heart for oxygenation outside the body. The procedure pushes oxygen through hollow plastic fibers that diffuse it into the blood and absorb carbon dioxide. ECMO is therefore an attempt to replicate the blood oxygenation a fetus receives through the placenta and umbilical cord. ECMO has been quickly adopted for adults with heart or lung failure, who now account for the bulk of ECMO cases. The largest hurdle for ECMO has been the tiny size of preterm infants' blood vessels, which means the cannulas to connect them to devices are also tiny (Zimmer 2021).

The artificial placenta extends work on ECMO by immersing infants in artificial amniotic fluid to protect their lungs and remove urine, while their blood is oxygenated and infused with nutrition through their umbilicus. The

first breakthrough in this strategy was achieved in the 1980s by Yoshinori Kuwabara, who kept premature goat fetuses alive in fluid-filled sacks for three weeks. Many groups are currently attempting to perfect versions of artificial placentas and amniotic fluid (Fallon and Mychaliska 2021). The Biobag system at the Children's Hospital in Philadelphia, for instance, immerses the preterm fetus in simulated amniotic fluid, with oxygenated blood being pumped through by the fetus' own heart rather than mechanically. In addition to oxygen and sugar, the blood also requires a comprehensive set of amino acids, lipids, and vitamins (de Bie et al. 2021).

The artificial womb, then, would be a set of technologies that allow embryos and fetuses to develop between the blastocyst stage and the current 22 week limit of NICU viability.

3. THE POLITICS OF ARTIFICIAL WOMBS

3.1. Viability, Fetal Personhood, and Roe v Wade

In 1973 the Roe v. Wade Supreme Court decision decriminalized abortion in the United States. That decision limited the unconditional right to abortion to the point of "viability," the point at which the fetus was viable outside the mother's body. In the early 1970s that point was considered to be 24 weeks of pregnancy, so abortions in the third trimester, after 24 weeks, were restricted to cases that threaten the mother's life or health. However, as noted, premature deliveries at 23 weeks are often admitted to NICUs, while miscarriages at 22 weeks or earlier are considered beyond saving. In other words, technology has moved the viability line by one week in the last 50 years. Artificial wombs would erase that line altogether.

The debate over fetal viability does not necessarily have anything to do with the right to abortion. The debate has more generally been between the "pro-life" position that embryos are moral persons with a right to life at the moment of conception, and the "pro-choice" position that a mother's right to bodily autonomy trumps any potential right to life that an embryo or fetus might have. The latter view was famously articulated in the 1971 essay "A Defense of Abortion" (Thomson 1971) which explored a thought experiment about people forced to be the life support system for other adults without their consent, a circumstance that most find so horrifying that it should give pause about forcing women to bear unwanted pregnancies. If one accepts that the right to bodily autonomy applies, even if refusing to be a life support system means that another person will die, then one may invoke the principle of double effect, i.e. the act was not intended to kill but only to refuse to let live.

The abortion-rights position argues that the moral status of the fetus is ir-

relevant, and few in the pro-choice camp have taken up arguments from the bioethics literature to directly challenge the pro-life assertion of personhood. Bioethicists have proposed many possible conditions for a being to have moral standing, many ways of knowing about those conditions, and different moral obligations for the different statuses. The most extreme, or consistent, personhood theorists argue that even newborns are not yet fully formed moral persons, lacking the psychological requisites for personal identity, and therefore abortion is permissible, and even infanticide under at least some conditions (Tooley 1972). Others attempt a more empirical examination of what we know about the developing nervous systems, and when a fetus might be capable of the kinds of thoughts and feelings that would constitute "brain birth," parallel to our practice around declaring the "brain dead" to have lost moral personhood (Jones 1989). For those who assert that "brain birth" occurs at some point in the third trimester, for instance, the mother's bodily autonomy can still trump fetal rights. But partial fetal moral status would at least oblige parents and medical personnel to attempt to rescue miscarriages that occur after that point. The Reagan administration brought this issue into sharp focus when it attempted to aggressively punish parents and physicians who tried to withdraw life-sustaining care from severely disabled premature infants in neonatal intensive care units (White 2011).

A parallel debate over the ownership of reproductive and fetal material has been less visible but will be very important in regulating artificial wombs. When the material is outside a mother's body, as in in-vitro fertilization and frozen embryos, the issue of bodily autonomy becomes more or less moot. Courts have been obliged, for instance, to judge the ownership of frozen embryos created by would-be parents who now disagree over whether they should be brought to term. If the embryo or fetus is a moral person, then while their parents may have the right to make life and death medical decisions on their behalf, they cannot be "owned" and have a presumptive right to life. Frozen embryos may also include reproductive material from a third party contracted to help the parent(s) conceive a healthy child. After birth, there are now decades of cases of surrogate mothers suing for custody on the grounds that carrying and bearing a child gives them custodial rights regardless of any contract they may have signed with would-be parents or their genetic relationship to the child.

Despite decades of litigation, there is little consensus in the United States and worldwide about the principles applicable to the ownership of embryos, fetuses, and infants. If they are persons, then the court is obliged to choose which medical decision (presumably life) and custodian is in their best interests. If every fertilized egg is a person, then parents might be obliged to bring them all to term, even though many are routinely discarded in attempts to have a single child. If they are property, then the court can apply the same principles as in the division of assets at divorce. While fathers may have not a right to determine the fate of a pregnancy, they may have equal rights in

determining the fate of a frozen embryo. Assaulting a woman and causing her to lose a pregnancy would either be murder or property damage, depending on fetal personhood.

However, if fetuses are something in between persons and property, then there is a fundamental conflict between the right to procreate, the right not to procreate, and claims from any contractual obligations (Sheinbach 1999). A 2015 case in Illinois for instance ruled that frozen embryos should be given to the mother, over her ex-boyfriend's objection, since subsequent sterility made them her last chance to conceive. A 1992 ruling in Tennessee held, on the other hand, that a mother could not give her frozen embryos to an infertile couple because the genetic father had a right not to conceive (Chen 2016).

In a future with artificial wombs the debate will return to these core, intertwined questions; when does developing fetal material become morally significant and who "owns" that material until that point, if anyone.

3.2. Beyond Roe v Wade: Artificial Wombs and Fetal Rescue

While artificial wombs were initially proposed as a way to free women from pregnancy and usher in gender equality, they have ironically been eagerly anticipated by some conservative opponents of abortion as a means to eventually oblige the "rescue" of fetuses from mothers who intend to abort them (Simkulet 2020; Rodger 2020). Currently, the U.S. Supreme Court is deciding on the constitutionality of a Mississippi law that bans abortion after 15 weeks of pregnancy because "scientific advances show that an unborn child has taken on the human form and features months before viability" (Girard 2021). Fetal personhood could still be trumped by bodily autonomy claims, but artificial wombs would weaken the autonomy argument and open the door to "fetal rescue." Forcing women to undergo an unwanted medical procedure to steal their genetic progeny would still, hopefully, be politically unpopular.

3.3. Ectogenesis As an Expansion of Reproductive Freedom

The Universal Declaration of Human Rights, as adopted by the United Nations in 1948, articulates a right "to marry and to found a family." It does not specify a right to use reproductive technology, although such a right can be construed for the broader principles of human rights. Benjamin, for instance, argues that U.S. Constitutional principles would protect would-be parents' rights to use artificial wombs, once that technology exists and is safe. "The right to use ectogenesis to reproduce involves the rights to procreate, not to gestate, and to make child-rearing decisions autonomously without state interference…the right to utilize this technology… would be logical given the

existing reproductive privacy jurisprudence" (Benjamin 2020).

Artificial wombs would expand reproductive options not just for cisgender parents, unwilling or unable to conceive and carry children to term, but also for nontraditional parents such as single men, gay male couples, and transgender people (Kimberly, Sutter, and Quinn 2020). Non-traditional parents' access to reproductive technologies is currently restricted in many countries. It was only in 2021, for instance, that France allowed single women and lesbians access to assisted reproduction (Darmanian 2021). Artificial wombs would also contribute to transcending the gender binary by separating gestation from gender (Dvorsky and Hughes 2008; MacKay 2020).

4. Conclusions

For almost one hundred years the artificial womb has been promoted as a way to expand reproductive freedom and gender equality, and derided as a dystopian technology that would encourage totalitarianism and dehumanization. Progress towards the goal of healthy extrauterine gestation between the second and 23rd weeks after fertilization has been slow, although success seems likely this century. As this technology advances the ethical and political questions about its impacts will become more pressing, obliging legal redefinitions of the rights and obligations of parents, and the status of the fetus.

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