

Eve

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# Eve

The Disobedient Future of Birth

Claire Horn

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# A Note on Language

Throughout these chapters I've endeavoured to use gender-inclusive terms when I talk about pregnancy and reproductive health. To say 'pregnant people' and 'birthing people' is to acknowledge that cis women are not the only people who can become pregnant and require antenatal care, which is a fact.

With regard to writing about race, I've aimed to be as specific as I can wherever possible. However, this book engages with medical and legal data, an area in which specificity is woefully lacking. For example, the US Centers for Disease Control and Prevention (CDC) uses 'American Indian' and 'Alaska Native' as identity categories to track outcomes for neonates (newborns) and pregnant people, but with more than 500 federally recognised tribes in the United States, this does not leave us with precise and self-determined language, nor does it support identifying which specific groups are most impacted.

Finally, as will soon become clear, I am not a scientist: I use the terms 'artificial womb' and 'ectogenesis', although these are not always the words that scientists working on external gestation would ascribe to their work.

# Of Incubators, Orchids and Artificial Wombs

If you are reading this, the one thing that I know to be true about you is that someone, somewhere, carried you in their body before you were a person. Someone gave birth to you.

As I write this sentence I can feel my own baby move in my uterus. I don't know whether the person who gestated you is your mother or not, but I know they too probably felt the indescribable sensation of your limbs shifting under their skin. And I know that before you were big enough to be felt – before you had even taken the shape of a human baby – their body was your home.

I know that, at some point, they probably wondered when, exactly, you would deign to be born. I feel as though I have been pregnant for more than a year, and simultaneously as if this period of my life is passing in the blink of an eye. Pregnancy time, as a friend put it recently, is all lies. Our due dates are guesstimates and, for the most part, we simply do not know when our babies will decide to show up. They could arrive closer to what is really ten months or they could arrive dangerously far in advance.

If you close your eyes, you can probably conjure up an

image of an incubator. But not so very long ago, in nineteenth-century London during the first years of human incubation, it was strange indeed to witness a baby enclosed in a miniature transparent box. It was much stranger still to learn that after a few weeks of being warmed in this way, a previously struggling infant could emerge ready to be reunited with its parents.

Before the introduction of the first modern incubators in Europe in the late 1880s, mothers and midwives practised the common-sense principle that an ailing baby might be helped by keeping it swaddled and warm. However, the incubators that arrived at the turn of the century were thrilling to a public that could not fathom the survival of an infant in this space of air, metal and glass, between its mother's womb and the world.

The apocryphal story holds that the French physician Stéphane Tarnier visited the Paris Zoo with his mind on the high death rates among newborns in the wards of the Paris Maternity Hospital. Watching how chicks thrived in a warming contraption fashioned by the zookeeper Odile Martin, Tarnier asked whether it might be possible to craft a similar kind of structure for infants. Martin obliged and the *couveuse*, or 'brooding-hen' incubator, made its debut. While Tarnier's incubators would begin in a hospital setting, they soon became a fixture of a much more unexpected locale: the fairground. In 1896 the paediatrician Alexandre Lion and the self-proclaimed physician Martin Coney would open the *Kinderbrutenstalt* (child hatchery) to eager droves of spectators at the Great Industrial Exposition in Berlin. Coney would eventually return home to the United States, where he established a permanent 'incubator baby show' at Coney Island's Luna amusement park in 1903. When the first show was launched in Britain at the Victorian Era Exhibition at Earls Court in 1897, the public was so enraptured that a song about breeding a nation 'by means of incubation' became a swift hit that summer.



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Contemporary commentators, divided between horror and delight, fed the craze. A rumour swirled that it had become possible to grow babies like orchids in a hothouse: treat them with light, heat and a safe corral and up they sprouted. *The Graphic* magazine published an image of a well-heeled crowd gathered behind a velvet rope, leaning keenly towards the peculiar glass-fronted boxes. Palm trees add a verdant dimension to an otherwise mechanical picture. Nurses stand in neat rows, seemingly poised for action. The small clocks pinned to their white aprons remind the viewer that these are not people at leisure, but professionals at work. Below, the caption reads: 'An Artificial Foster-Mother'. This was the root of what made the technology so enchanting. It seemed possible, both to the day-trippers who marvelled at the babies in their warming boxes, and to the physicians who managed them, that infants might soon be grown outside the human body.

A full-term pregnancy is forty weeks, and Tarnier's incubators would likely have held infants not less than thirty-eight weeks old. Yet the physician boasted that he was on the cusp of enabling almost the entire latter half of gestation to occur through his technology. Despite the caveats of other emerging experts on the incubator, commentators in medical publications like *The Lancet* and the *British Medical Journal* were quick to believe that an artificial womb had arrived. One contributor argued that the only change that might make the technology more precisely like a human uterus would be if infants were suspended in artificial amniotic fluid. But, another author conceded, this could cause the baby to drown, so the innovative use of warm air in glass was the closest possible imitation. With this feat already accomplished, surely it wouldn't be long before the entire process of gestation could be facilitated through these means. The Victorians may have been comically optimistic in their certainty that

artificial wombs were just around the corner, but in the twenty-first century we have finally arrived at the brink of this peculiar dream becoming plausible.

In 2017 researchers at the Children's Hospital of Philadelphia (CHOP) released news of successful animal trials of the first partial artificial womb, a platform they dubbed 'the bio-bag'. They had achieved what even the most confident physicians of the 1890s believed to be impossible: they had re-created the liquid environment of the uterus. Any baby born before thirty-seven weeks is considered premature, with any birth before thirty-two weeks considered very preterm. From twenty-eight weeks, in a well-equipped hospital, an infant has a good chance of survival. While contemporary technologies can be used to assist extremely preterm babies born as early as twenty-two weeks, mortality remains high. The best that can currently be done for these infants is the provision of emergency care to treat the complications of being born before their organs have developed sufficiently to function in the outside world. With an estimated survival rate of just 10 per cent for babies born at twenty-two weeks, approximately one-third of those who live suffer significant health issues.

The success of the bio-bag animal trials raised the possibility that these health complications could be prevented, and that a neonate born nearly four months before their due date could recover in good health. An extremely premature lamb fetus was placed inside a translucent polyurethane bag and was buoyed by artificial amniotic fluid. Like the fluids that surround a baby in a pregnant person's body, this synthetic liquid delivered nutrients to the neonate. After much trial and error, researchers were able to use an external pump that fed oxygen into the bio-bag and flushed out toxins to create a workable approximation of the placenta, the extraordinary organ that grows in pregnancy

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to connect the fetus to the uterus. The technology ultimately allowed scientists to successfully gestate lamb fetuses from the equivalent of approximately twenty-two to twenty-four weeks in a human, until they were fully developed (at the equivalent of around twenty-eight weeks) and could be extracted in good health. In 2019 the group announced a second round of promising animal trials. The process of securing Food and Drug Administration (FDA) approval for trials with human fetuses is now under way, with hopes that this work might begin within the next few years.

Meanwhile, as of 2022, a team working between Japan and Australia has completed two animal trials of a similar platform, which they are calling ‘Ex-vivo Uterine Environment Therapy’, or EVE. Unlike the boastful claims of Stéphane Tarnier, the group has been careful to caveat that they have no intention of ‘replacing’ human pregnancy. Of course their emphasis that this project is in no way intended to facilitate gestation outside the body is somewhat undercut by the curious choice to name it after the biblical first woman.

Their research has shown promise with animal fetuses at an even lower gestational threshold and birth weight than those in the bio-bag experiments, with the intention to treat human babies born as early as twenty-one weeks – just shy of halfway through a full-term pregnancy. And in the Netherlands in autumn 2019 a multidisciplinary research team announced plans to create their own partial artificial womb within five years. Using strikingly lifelike 3D-printed model neonates equipped with sensors, and replicating features such as maternal heartbeat sounds, the team plans to create a technology that can not only gestate extremely premature babies, but also track the specific needs of a given infant and readjust the conditions accordingly.

These projects are distinct from one another in experimental

design. They share the potential, however, to revolutionise what is possible in the care of extremely preterm babies. Existing forms of neonatal care are emergency interventions. The baby is given treatments to stave off the effects of being born with significantly underdeveloped organs. The artificial womb, in contrast, extends the period of gestation to prevent these complications from arising to begin with. If it works, it will enable the infant to keep growing as though it had not yet been born. And with scientists anticipating human trials within the next few years, artificial-womb technology is no longer purely speculative. Researchers are finally on the cusp of achieving what Stéphane Tarnier could only imagine 140 years ago. Victorians were impressed by the sight of almost full-term babies in glass boxes – imagine how transfixed they would have been by the research now in progress. The ‘before’ and ‘after’ images released by the bio-bag team were eerie and briefly ubiquitous. In the first, a floating, pink-skinned, wrinkled lamb fetus sleeps adrift in a transparent bag. In the second, it has grown soft white wool and its body presses against the plastic surface, waiting to be born. These pictures evoke much the same reaction that people once felt when they first encountered incubators: the curious sensation of peering into the future.

It isn't just studies in neonatology that have brought us closer than ever before to achieving artificial gestation. The development of *in vitro* fertilisation in the 1970s led to years of ethical debate, culminating in the adoption of the ‘14-day rule’ for embryo research as a legal regulation in twelve countries including the UK, and as a strict scientific guideline in at least five countries including the US. The rule has meant that scientists could face sanctions for growing human embryos in a laboratory setting beyond two weeks. For approximately forty years there was no cause to question this limit. Despite their best efforts, no

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scientist had been able to grow embryos beyond nine days. But in 2016 embryologists at Cambridge and Rockefeller universities respectively reached thirteen days, ending their experiments only to avoid violating the 14-day rule. This was a remarkable feat. Before this breakthrough, scientists had assumed that after around seven days – the point when an embryo would normally implant in a pregnant person’s uterus – it would need feedback from their tissue to continue growing. Instead, within a nourishing lab-created culture, the cells were able to implant in a dish and continue to organise themselves, suggesting that embryos might be able to grow outside the human body much longer than previously believed.

In May 2021 a researcher at Weizmann Institute of Science in Israel made an even more jaw-dropping announcement. After seven years of study he and his team created an artificial womb in which they successfully grew mice from embryos into fully formed fetuses. Each embryo was placed in a spinning, liquid-filled bottle, carefully modulated to ensure optimal nutrients and temperature. Mouse gestation is substantively shorter than gestation in humans: we take approximately 273 days to form fully, while they take nineteen. The results of this experiment were no less extraordinary for this shortened timeline. For the first time in history, an animal was grown from an embryo to a fetus in a laboratory setting. The mice were gestated from day five to day eleven. Next, scientists plan to take them to the full term of nineteen days. And after that? The group ultimately hopes to run the experiment with human embryos.

When the Cambridge and Rockefeller researchers first hit the 14-day limit, they kicked off a heated debate in the scientific and bioethical communities over whether it was time to revisit the limit. Some scientists argued that now that we had the ability to gestate a human embryo in culture for fourteen days, we should

go further. After all, we know more about the bottom of the ocean and what is happening in outer space than we do about the earliest stages of development. Others insisted that there was still plenty to study in the first two weeks of growth, and it was a slippery slope to go beyond this point. And many took the practical view that there was a middle path: that we might be able to continue research without creating new ethical quandaries, but public opinion needed to be part of the conversation.

In May 2021 these years of deliberation culminated in the International Society for Stem Cell Research's release of updated guidelines advising that the 14-day rule be dropped. In effect, this marked the beginning of a sea change. The ISSCR is the largest global membership body for stem-cell researchers. And in countries like the US, where the 14-day rule is a strict scientific framework but is not enforced through law, the ISSCR's guidelines inform research. This does not mean that scientists will suddenly be free to cultivate embryos for as long as they choose, with reckless abandon. It does mean, though, that how much further we might go with embryo growth outside the body is now an open question.

These respective developments in neonatology and embryology have brought us to an unprecedented moment. We are five to ten years from the achievement of a partial artificial womb for humans, based on current estimates. Which means that not so far down the road, we will probably be able to sustain a fetus outside a human body for nearly half of its gestation. If, as seems more and more possible, one day the growth of embryos in a laboratory and the maintenance of infants in a neonatal ward meet in the middle, we will achieve full ectogenesis: external gestation. Babies might be gestated, from conception to birth, without ever being carried in a person's uterus. While growing a human from the embryonic stage through to full

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term may sound futuristic – impossible even – it is closer than ever before.

After announcing their animal trials in 2017, the research team behind the bio-bag immediately found themselves caught up in a media buzz. You can see the dismay on Emily Partridge and Alan Flake's faces in some of their early interviews, and who can blame them? There they were, ready to explain that their technology, if successful, could drastically improve prospects for extremely premature babies and their parents. Yet interviewers were generally less interested in asking about, for instance, what went into the artificial amniotic fluid they had created, and more interested in whether they intended to grow babies from conception. Was this, eager journalists wanted to know, the beginning of *Brave New World*?

*Brave New World* was shorthand for the kind of bleak future with ectogenesis that we might all hope to avoid – one where infants are generated in jars, guarded against any kind of loving relationship and destined to become adults who are thoroughly brainwashed subjects of the state. In Huxley's world, artificial wombs are symbolic of the worst aspects of humanity. The CHOP research team has been clear from the beginning that they have no intention of contributing to ectogenesis. 'No one,' Partridge commented back in 2017, 'is trying to do that.' Describing artificial gestation as 'the stuff of science fiction', she was quick to question whether such a feat was even possible. Since releasing their initial study, the group has renamed their project EXTra-uterine Environment for Neonatal Development (EXTEND), emphasising the technology's intended purpose as a means of bridging, or extending, the development already facilitated for the extremely preterm baby within the pregnant person's womb.

Magdalena Zernicka-Goetz, the Cambridge scientist who led the first team to report reaching the thirteen-day mark, has also

commented that her lab is certainly not trying to pursue ectogenesis, and that to do so would be incredibly scientifically complex. She is, of course, correct. Developmentally, there is a substantive difference between an embryo at thirteen days and a fetus at twenty-three weeks. Just because we have made advancements at either end of gestation does not mean that full ectogenesis is inevitable. Scientists were surprised that the embryos they grew in culture managed to continue developing on their own – for a week longer than expected – but that doesn't necessarily mean there is not some point at which it would become untenable to sustain embryos without implanting them in a person's body. The truth is: we don't know. And while *ex utero* gestation of preterm neonates seems poised to make it possible for infants to be born and survive at earlier and earlier stages, there could well be a limit to how far that threshold can be lowered.

To date, it is considered impossible for a fetus at less than twenty-one weeks' gestation to survive, and each week within the uterus involves new milestones. As researchers working on artificial-womb platforms have been quick to point out, a fetus below approximately twenty-one weeks would likely have veins too small to connect to the lifesaving technology. But even if these scientists do not intend to achieve ectogenesis, others do. The team that announced the successful growth of mice embryos using artificial wombs, though wary of the ethical issues posed by their work, have been explicit that they wish to gestate human embryos into fetuses.

Even aside from whether individual researchers intend to pursue ectogenesis, the last thirty or so years have taught us that scientific innovation can move from futuristic to commonplace with extraordinary speed. Those of us who were kids in the 1990s remember the sudden transition from a handful of classmates having screeching dial-up internet to a smartphone in every



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hand. Researchers well know that technological breakthroughs often lead to very different ends than they originally intended. Scientific progress frequently outpaces our regulatory systems, and even our imaginations. The truth is that we have been dreaming of artificial-womb technology since rows of warming boxes prompted the rumour that babies could be cultivated like flowers in greenhouses. But now that we are finally reaching the scientific capacity to create an artificial womb, the question is no longer: *Is this innovation possible?* The question is: *Are we ready?*

In the 1970s twenty-five-year-old socialist feminist Shulamith Firestone penned her manifesto. ‘Pregnancy,’ she wrote, ‘is barbaric.’<sup>1</sup> Firestone remarked that as a direct consequence of the dominance of men in scientific research, we could travel to the moon, but we still hadn’t found a better way to gestate humans. In 2018, nearly fifty years after Firestone made these claims, I sat in a crowd of geneticists, embryologists and humanities scholars working under the broad umbrella of topics in reproduction. The audience watched in dumbfounded silence as bioethicist Anna Smajdor made a new case for Firestone’s forty-year-old argument. The physical consequences of pregnancy and birth ranged from sustained nausea, dizziness and exhaustion, to trauma, permanent injury and death. How was it that we hadn’t ‘fixed’ this yet? Nodding to the research of scientists in attendance, Smajdor made a confident declaration: sexual reproduction was on its way out, and a new era of automated gestation was soon to begin.

As the audience queued for coffee, they debated her proposal. Some women in the group commented that they had enjoyed being pregnant, that carrying a child had been a profoundly challenging but rewarding experience. Others described relentless morning sickness, haemorrhoids, ‘feeling like an elephant’ and being treated as public property – suddenly every stranger

had an opinion on their bodies and behaviour. In weighing their experiences of pregnancy and birth, the perspectives of each of these women had been shaped by the sense that there was simply no other way. What makes Firestone and Smajdor's argument so provocative is their invitation to think beyond this assumption, to ask how our attitudes towards pregnancy might change if, in fact, there *was* another way. Considered in the context of the scientific research of the last several years, Smajdor's prediction about the end of sexual reproduction is not so hard to imagine after all.

Would we end human pregnancy entirely if we could? Could any person of any gender be responsible for gestating a fetus to term? These debates, after Smajdor's speech in 2018, reflect how the very idea of an artificial womb forces us to question our most basic assumptions about human life. This is not just about the possibility of a collective existential crisis. The social and ethical questions raised by both partial artificial wombs and ectogenesis have real-world implications. Developing these technologies will require trials on extremely premature babies. What are the ethics of asking parents to consent to partial artificial-womb treatment? Rates of preterm birth and maternal morbidity and mortality are vastly unequal, with more than 90 per cent of preventable deaths of infants and birthing people occurring in the Global South. The partial artificial wombs that are currently in development are a true game-changer for neonatal care: they could save the lives of countless preterm babies that would otherwise die. But this technology is likely to be extremely costly and to require a substantive infrastructure in order to be used safely.

Whose babies will have access to this treatment? Is there a risk that this technology could increase existing health inequity by improving care for some and not for others? Within wealthy nations like England, which have much lower rates of preterm

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birth and maternal mortality overall, there is an unconscionable racialised disparity in these health outcomes. As of 2022, Black women in Britain and their babies were four times more likely to die or experience serious medical complications than white women. If artificial-womb technology is available in high-income nations like Britain, would all pregnant people be granted equal access?

And research at the other end of gestation prompts another set of pressing questions. Now that the ISSCR has recommended lifting the 14-day limit, will there be a new global consensus on how long human embryos can be grown in laboratories? Would it be ethically permissible to cultivate a human from the embryonic stage until it became a fetus with fully formed organs, as scientists have already achieved with mice? If a baby was grown through ectogenesis, who would its parents be, and who would be responsible if anything went wrong? Would people be able to choose to use the technology to gestate and, if so, under what circumstances? Would access be limited to people who were unable to carry a pregnancy, or could you simply decide which option you preferred? Even as of 2022, some nations continue to have laws in place that criminalise pregnant people who are believed to be engaging in behaviour that might harm their fetuses. If artificial wombs were widely available, could women perceived to be 'unfit' mothers be coerced into using them? And if a fetus could survive without being dependent on a pregnant person's body, how would that impact upon reproductive rights?

Considered together, the questions that artificial wombs raise for society – for law, medicine and ethics – could have a profound impact on what it means to be human. Today it is a fundamental and uncontested truth that someone gestated you. They navigated the physical, emotional and social ups and downs of being pregnant. They ate and drank and moved, and

you reflexively did these things with them. Their heartbeat was your first sound, their uterus was the first place you hiccupped, stretched and spun. This was your first relationship. This was the first person to mediate between you and everything else. What if, alongside all the other things that I cannot possibly know about you, I did not know whether you were gestated by a person or by a technology?

With the partial artificial womb in the immediate future, and progress towards full ectogenesis well under way, we need to begin thinking about the societal impact of these technologies. This is the moment to engage in these difficult conversations. Debates over the uses and dangers of artificial wombs have already begun in academic journals and lecture halls. But conversations that tackle all the complicated questions that ectogenesis raises need to happen in public space. We might reasonably hope that this technology would be welcomed for the way it could benefit the health of neonates and of pregnant people. Many of the loudest voices on the topic of artificial wombs, however, are conservative bioethicists and media commentators who have proposed regressive uses that would undermine the health of pregnant people, not support it.

Some lawyers and legal scholars, for instance, have been arguing for decades that the development of this technology will necessitate the rollback of reproductive rights. One American lawyer pontificated in the late 1970s that after artificial wombs, the law would compel women seeking an abortion to have their fetuses extracted, to continue to grow through ectogenesis instead. The idea that artificial wombs would make it okay for a person seeking abortion to be forced to undergo an operation to extract her fetus and submit to it being brought into the world in a machine is antiquated, cruel and anti-feminist. We could perhaps write off this argument as a relic of a distant past, if not

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for the fact that since the announcement of the successful animal trials of the first partial artificial wombs in 2017, legal scholars have begun making this very same claim once again. At a conference in 2018 I sat in a stuffy room while a bioethicist explained that these promising innovations meant that, in the not-so-distant future, abortion could be forbidden. This argument was especially unsettling given that, in many countries in the world, people are still struggling for basic access to abortion care. Just months after the final draft of this book was completed in April 2022, the US Supreme Court overturned *Roe v. Wade*, the judgement that had protected a private right to abortion since 1973. Their ruling means that people who find themselves pregnant in anti-abortion states face the threat of forced gestation and birth, or criminalisation for terminating their pregnancies in defiance of unjust laws. Artificial wombs are being researched in a world where people's bare rights to decide whether to continue or end a pregnancy are being stripped away. Those who were not watching the landscape of reproductive rights in the United States were shocked by the fall of *Roe*. But the court's decision followed a decades-long erosion of both access and rights to abortion. The Supreme Court's recent ruling is a stark reminder of what can happen when we look away, or assume that the needle of progress will always move forward. Regressive political actors stand ready to use emerging technologies to undermine our human rights. What kind of grim future would it be if, instead of creating a world where no one is criminalised for trying to control their own reproductive life, we created one where abortion was universally banned and people were forced to have their genetic children gestated against their will?

These are not the kinds of conversations that should be left to conservative bioethicists, legal scholars and researchers alone. When the ISSCR announced in 2021 that they were advising

that the 14-day rule be lifted, they emphasised the importance of public consultation. And even scientific researchers who are sceptical of whether full ectogenesis will ever be possible have acknowledged the importance of discussing the social and ethical issues presented by artificial wombs. After all, gestation is one of the few experiences that can be said to impact everyone. For each of us to exist, someone gave birth to us. If that changes, so does life as we know it.

Modern though we may be, if the commentaries that have followed each recent advancement in neonatology and embryology are anything to go by, many of us are just as fascinated and perplexed by the idea of babies growing in artificial wombs as those eager viewers of incubator shows at the turn of the twentieth century. Over the last five years, in the pages of the *Guardian*, the BBC, the *Daily Mail*, *The New York Times*, *Discover* and the *New Statesman*, to name but a few, reporters have speculatively weighed the possibilities of the technology. Alongside images of the bio-bag, headlines have been punctuated by another clip featuring gynaecologist Guid Oei, lead researcher on the Dutch *ex utero* gestation project, standing before what appears to be a giant bouquet of whimsical red balloons interspersed with plastic cords. Despite what is implied in some of this media coverage, the design is not a working prototype, but a speculative installation created by Lisa Mandemaker and the Next Nature Network. These images were eagerly shared by the press, amid opinion pieces on the future of reproductive rights, gender equality and human nature. Pictures of the doctor posed before the floating artificial wombs – like those of the lamb in its liquid environment – are in notable parallel with *The Graphic's* nineteenth-century illustration of the 'Artificial Foster-Mother'.

As the questions put to the bio-bag researchers tell us all too well, when most people today think of artificial wombs, they

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think of *Brave New World*. But there are lesser-known visions of ectogenesis that crop up in sci-fi and fantasy. In Marge Piercy's 1976 novel *Woman on the Edge of Time*, artificial wombs are a tool of empowerment. The technology is a way out of a world where mothers are left to shoulder the trials of pregnancy and the pain of childbirth alone and are subsequently held responsible for anything that happens to their children for the rest of their lives. In the classless, genderless society that Piercy imagines, babies are gestated through ectogenesis and are assigned three parents of any gender who are responsible for 'mothering' them, with the help of the entire community. Since no one is solely responsible for carrying a pregnancy, everyone is responsible for caring for infants once they are born.

No one asks contemporary researchers if their technology might open the door to *Woman on the Edge of Time*. Why is it so much easier for people to imagine a world where artificial wombs lead to dystopian authoritarianism than a feminist utopia of communal child-rearing? Both Huxley and Piercy's visions of a future with artificial wombs are especially interesting in that, while contradictory, their respective speculations are based on the realities of their present day. We expect this of good sci-fi. After all, what really keeps a reader or viewer rapt is a world that bears some resemblance to our own.

Piercy and Huxley began by exploring the question of what might happen if an artificial womb was dropped into their contemporary contexts. Huxley wrote in 1932, in the wake of many years of popular support for eugenics in the UK, and as the Nazis grew in power. From this place he envisioned the worst ways that a totalitarian society might apply an artificial womb to control reproduction and oppress the vulnerable. Piercy, in the 1970s, wrote from an America in the thick of feminist and civil-rights movements. From there, she imagined that in a better kind

of society – the society that activists might build – an artificial womb could be used to make the work of care more communal, to undo the association of motherhood with women only. At the precipice of external gestation becoming a reality, we must ask the same question that formed the basis of these two visions of ectogenesis written many decades apart. If we had access to artificial-womb technology, how would we use it?

This book starts from the premise that artificial wombs will only be as innovative as the social context in which they arrive. In an ideal world, partial artificial wombs would be accessible to all pregnant people, to be freely chosen as a means of saving their lives and health and those of their prematurely born babies. And in the further future, ectogenesis would be a tool that people could use to build families of their choosing, regardless of their gender. It would be a means of realising kinship through love and intent, above genetics and designated sex. But we do not live in an ideal world.

Each chapter of this book explores a different facet of how our society needs to change before the introduction of artificial-womb technology. It spans backwards in time to the incubator baby-show craze of the 1890s, and to the origin of the word ‘ectogenesis’ in a lecture theatre in 1923. And it reaches forward to the scientific future that might be, with babies grown from conception to term through external gestation. Along the way, it dives into the ways in which the laws, policies and institutions that shape our world currently limit the possibilities for ectogenesis and put us at risk of the technology worsening existing inequities and undermining progressive human rights. Ultimately, it traces a path towards the kind of future – beyond the inadequate reality we have created, and beyond the limits of our own imaginations – in which artificial wombs might change humanity for the better, after all.