The Idea of Ectogenesis in Daedalus; or Science and The Future (1924), by John Burdon Sanderson Haldane

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In 1924, John Burdon Sanderson Haldane, aka JBS Haldane, published *Daedalus; or Science and The Future*, hereafter *Daedalus*, which was a written version of a lecture that he gave in 1923. In his book, Haldane offers his personal predictions about what science will be able to achieve by the year 2073. He proposes that scientists will be able to perform ectogenesis, which he defines as the gestation of an organism in an artificial environment. He argues that the development of ectogenesis will help improve the human species by facilitating the selective breeding of individuals with desirable traits. Haldane's vision of ectogenesis in *Daedalus* foreshadowed *in vitro* fertilization, or IVF, an assisted-reproductive technology in which scientists fertilize an egg in a laboratory dish, then implant the resulting embryo into a woman's uterus where it then develops into a fetus. As of 2025, physicians deliver over 500,000 infants per year who were conceived using assisted-reproductive technologies such as IVF. Haldane's concept of ectogenesis as he described it in *Daedalus* inspired both supportive and critical responses among readers and has shaped discussions about reproductive technologies down to the present day.

Background and Context

Haldane was a scientist and writer who studied genetics, evolutionary biology, and mathematics in England and India in the twentieth century. According to a biography of Haldane written by journalist Samanth Subramanian, Haldane's interest in the scientific disciplines began in his early childhood as he assisted his father, John Scott Haldane, with

his research in human physiology. In 1914, Haldane graduated with an undergraduate degree in classics from New College of Oxford University in Oxford, England. Following his graduation, Haldane spent the remainder of his career focused on the scientific disciplines. In 1923, he accepted a readership position in biochemistry at Cambridge University in Cambridge, England, and that same year, he presented his lecture *Daedalus* to the Cambridge Heretics, which was a society celebrating humanist ideals formed at the University of Cambridge in 1909. According to several biographers, Haldane identified as a socialist, Marxist, atheist, and secular humanist.

In the early twentieth century, various ideas and movements arose that influenced Haldane's writing of *Daedalus*, including eugenics. The conclusion of World War I at the end of 1918 led to a period of high rates of poverty and unemployment in England, which influenced the rise of those ideas. At that time, many intellectuals, scientists, and political leaders attributed social problems like poverty to the failures of inferior individuals and began to offer their support to the eugenics movement as a solution to improve the state of society. The eugenics movement sought to improve the human race through selective genetic breeding. Haldane's discussions in *Daedalus* of breeding superior humans reflects the popularity of eugenics when he wrote it.

Prior to the publication of *Daedalus*, scientists had already begun to experiment with hormones and fertility treatments. In the early twentieth century, researchers in Russia began attempting to develop practical methods of artificial insemination. In 1923, researchers successfully identified the female fertility hormone called estrogen, which later IVF procedures would require. Those discoveries raised questions about whether it might be possible to control reproduction through hormones and whether it might even be possible to gestate a human fetus outside a woman's body.

Haldane first introduced his ideas of ectogenesis in a lecture in 1923, and *Daedalus* is an expanded version of that lecture. On 4 February 1923, Haldane presented a lecture on his scientific predictions for the twentieth century to the Heretics Society at Cambridge. According to Subramanian's biography, the lecture was popular with scientists, students, and the public, so in 1924, Haldane published an expanded version of his lecture in the form of the book *Daedalus*. Although the book is a prediction of the future, Haldane framed the majority of *Daedalus* as an essay written from the perspective of a student from the year 2073 who is reflecting on the influence of science over the twentieth and twenty-first centuries. Subramanian writes that, with that format, Haldane could write about future predictions and commentary, but avoid their ethical implications because he was writing as a student.

The publication's title, *Daedalus*, refers to the Greek myth of Daedalus and Icarus, in which Daedalus, a mythical inventor, created wings of wax and feathers for himself and his son,

Icarus, to escape their captivity from King Minos. Daedalus was also the creator of a wooden machine in which Minos's wife mated with a bull to produce a creature called the Minotaur, and subsequently created the Minos's labyrinth to imprison the Minotaur. In the myth, before their escape, Daedalus warns Icarus to avoid the sun to prevent the wax on his wings from melting, but Icarus ignores his father's warnings and then dies. The myth serves as a cautionary tale against overreaching and highlights the importance of moderation. According to Krishna R. Dronamraju, a geneticist who trained under Haldane in India and wrote a biography about him, Haldane intended *Daedalus* in part as a warning to individuals in the twentieth century against the potential misuse of science as a solution to social problems.

Book Description

Daedalus is a ninety-three-page text that begins with a one-paragraph section called "Introduction" and then follows the format of an essay without any further divisions. In "Introduction," Haldane provides a short disclaimer that the publication is an expanded version of his 1923 lecture. Following "Introduction," Haldane presents his arguments and predictions about the future. First, he argues that scientific research will bring advancements to many aspects of human life and predicts a future with windmill-generated power and the decline of agriculture in favor of synthetic food. Next, he reflects on the genetic and embryological developments in the early twentieth century and predicts the creation of new species. From pages sixty-three to sixty-nine in his essay, Haldane presents his positive prediction for a future of ectogenesis driven by eugenic principles. He foresees the development of IVF and, as a result, selective breeding and a separation between sexual love and reproduction. Lastly, he argues that science will continue to revolutionize human life, but that it is impossible to predict the exact innovations of the future.

After his brief "Introduction," Haldane begins *Daedalus* with a reflection on World War I and argues that scientific research has the potential to destroy humanity. He states that many scientists have historically advised against the progress of scientific research for that reason. However, the economic and political systems in England would not support halting scientific research. He predicts that despite its capacity for destruction, scientific research will be primarily used in the future to benefit, rather than destroy, humankind.

Next, Haldane offers his predictions about the effects science and technology will have on human society. He foresees a future with the depletion of coal and oil fields as sources of energy and predicts that mechanical power will primarily derive from sources such as wind and sunlight. He writes that England will create windmills with electrical motors that provide clean water and electrical energy for the entire country. Haldane also offers his predictions for the influence of chemistry on the food industry and predicts a decline in agricultural industries in favor of cheaper, synthetically produced foods.

Haldane also discusses research in genetics and embryology and argues that those fields will continue to shape the future. He writes that scientists created significant biological advancements throughout the early twentieth century, including the development of hygienic medical protocols and treatments for various infectious diseases, such as sepsis and typhoid. Haldane states that the eugenics movement also gained support in the early 1900s, and because of that, scientists began experimenting with genetics and embryology. He discusses the discovery of sex linkage, or the concept that some traits in an organism are influenced by genes on sex chromosomes, and early experiments in the development of rabbit embryos, and then he predicts that scientists will have the ability to genetically create new species of organisms that will benefit society. Specifically, he predicts the development of a lab-formed algae called *Porphyrococcus*, which he explains will reproduce in the ocean and result in an explosion of the fish population, thus becoming one of England's primary food sources.

From pages sixty-three to sixty-nine, Haldane predicts a future marked by ectogenesis. He writes that the first attempt towards ectogenesis occurred in 1901 when Walter Heape, a researcher in England who studied embryology, performed one of the first mammalian embryo transfers in a rabbit. Haldane predicts that scientists will produce the first child from ectogenesis in the year 1951. He discusses his prediction by telling the story of two fictional scientists who obtained an ovary, or the female reproductive organ that produces eggs, from a deceased woman and preserved it for five years. He states that the scientists then extracted eggs from the preserved ovary and fertilized them with male sperm. He argues that by 2073, scientists across the world will be able to produce children via ectogenesis by removing a woman's ovary, maintaining it for up to twenty years in an artificial environment, taking an egg cell from it monthly, and then successfully growing embryos for nine months from those egg cells. He predicts that France will be the first country to officially adopt ectogenesis and will produce 60,000 children per year through ectogenesis by 1968.

As Haldane discusses ectogenesis, he also predicts the influence of eugenic principles on reproductive selection. Haldane predicts that less than thirty percent of children will be born naturally to a woman by the year 2073. Thus, most of the population will be born via ectogenesis. He states that ectogenesis would enable a eugenic approach to reproduction, where only females and males with superior genes would be selected for reproduction. He argues that ectogenesis is essential for society as he writes that society will collapse if the less superior members of a population continue reproducing. Additionally, Haldane writes that the reliance on ectogenesis for reproductive purposes will cause the separation of sexual love and reproduction, and thus, humans will be free to explore opportunities for love beyond reproduction, including sexless marriages. He argues that women should receive societal honor if scientists select their ovaries for ectogenesis. Finally, Haldane concludes his prediction of ectogenesis and eugenics by arguing that the human species will create an ideal human race by choosing only the best ancestors for the next generation.

Haldane concludes *Daedalus* by arguing that scientific development will continue to progress over the next few centuries, and that it is impossible to accurately predict a vision for the future. Haldane argues that scientists must engineer society through science and reproduction to achieve eugenics. Haldane discusses that it is impossible to achieve all the biological and technological advancements that he mentions, although it is humankind's intention to do so. In reference to the titular myth of *Daedalus*, Haldane ends the essay by stating that science rejects traditional morality represented by mythology. He writes that future scientists will more closely resemble Daedalus as they become proud of their scientific work, despite its consequences.

Legacy and Impact

Following the publication of *Daedalus*, Haldane's readers, many of whom were not scientists themselves, began to consider the possibility that science could destroy civilization, and many readers published responses to the publication. According to Subramanian, through *Daedalus,* Haldane became one of the first people in the twentieth century to express predictions for the scientific future, and as a result, his audience had mixed feelings of terror and curiosity regarding the potential future of scientific progress. In February 1924, after the publication of *Daedalus*, the philosopher Bertrand Russell published a response to *Daedalus* titled *Icarus, or the Future of Science*. In his publication, Russell was critical of Haldane's viewpoint on the future of science and argued that science had the potential to advance the interests of the elite, rather than enhance human happiness. Another view came from Aldous Huxley, a writer who studied philosophy and who was a colleague and friend of Haldane. In 1932, Huxley published *A Brave New World*, a novel that incorporated many Haldane's ideas, including of using ectogenesis to engineer superior humans, into the story of a fictional, dystopian society.

Haldane's predictions regarding ectogenesis were prescient. In the 1950s, scientists used IVF techniques to produce successful pregnancies in animal studies. In the 1960s and 1970s, researchers continued to apply IVF to successful animal studies and produced some failed attempts in humans. In 1978, Patrick Steptoe and Robert Edwards, who studied human reproduction in England, performed the first successful IVF procedure in a human, resulting in the birth of the first human infant born via IVF, Louise Brown. Scientists have also attempted to achieve ectogenesis through artificial uterus research, which involves placing a fetus in an external environment that replicates a natural uterus to support the fetus during gestation. In 2017, the Children's Hospital of Philadelphia in Philadelphia, Pennsylvania, created one of the first artificial uteruses, called the Biobag, that supported fetal lambs demonstrating normal growth and development. The Biobag experiment was reportedly successful, and since then, researchers continue to conduct animal studies to evaluate the ability of artificial uteruses to support a fetus. As of 2025, complete ectogenesis, or growing a fetus entirely in an external

environment, has not been achieved in either animals or humans.

Daedalus was one of the first scientific publications that introduced ideas of ectogenesis, including use of assisted-reproduction techniques. At its time of publication, the essay incited discussions regarding the role of scientific progress in advancing human happiness. As of 2025, scientists have developed various technologies related to Haldane's ideas about ectogenesis, including IVF and artificial uteruses. *Daedalus* is an example of how scientific predictions can produce discussions amongst intellectuals and the public that shape the way new technologies, including reproductive technologies, develop and are received.

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