

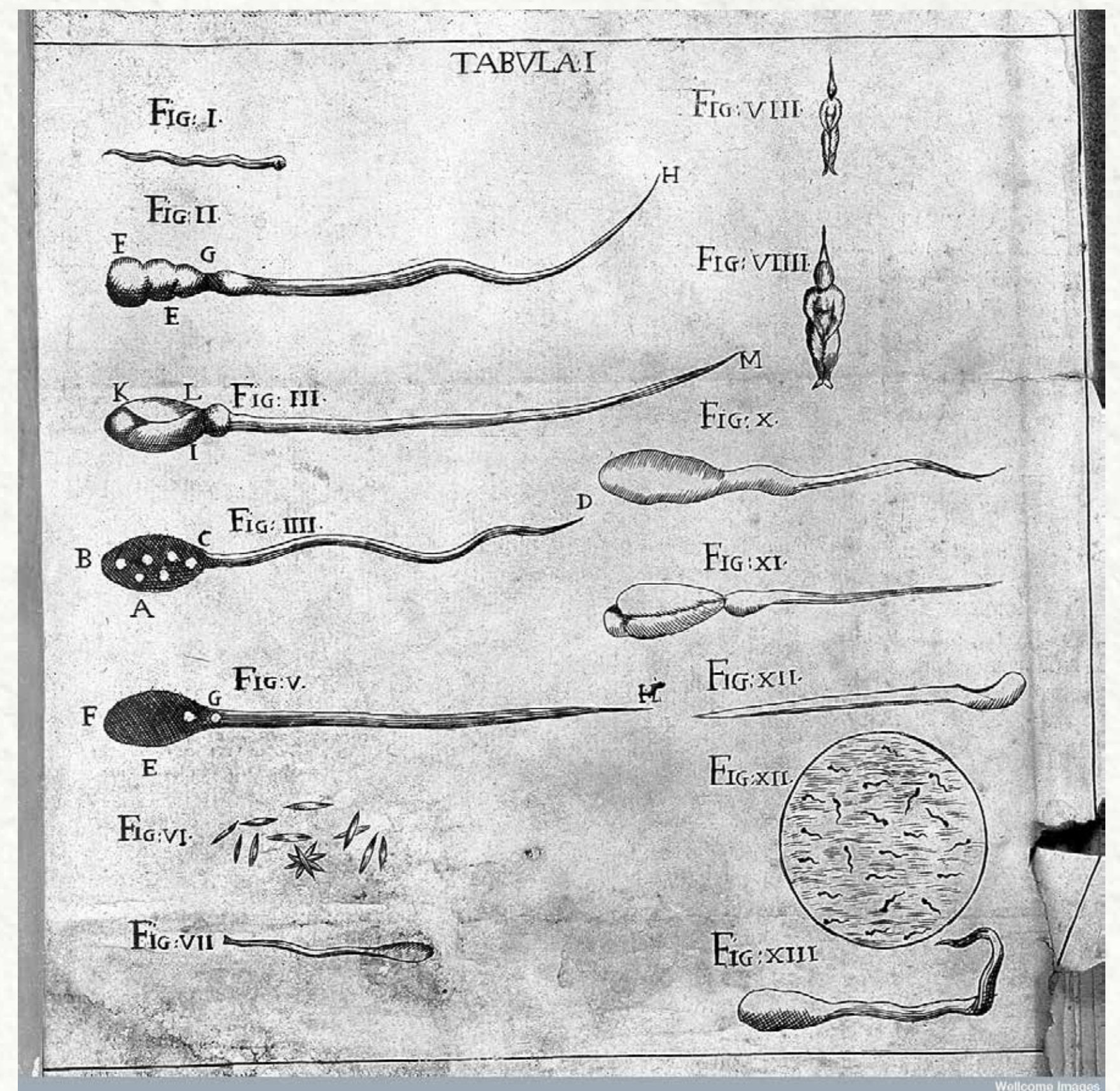
Spermists, Ovists, and Heredity

Today, the fertilization process is common knowledge: sperm and egg cells carrying genes from each parent combine to create their offspring. However, before scientists gained an understanding of cells, genes, and DNA, people had no mechanism for understanding conception. Aristotle, considered a medical authority for thousands of years, thought that a man's contribution to an embryo was its form or spiritual essence, while the woman only contributed the raw material, its flesh. Theories derived from Aristotle were known as epigenesis because they involved the shaping of raw material, part by part, into a human being.

By the seventeenth century, scientists were beginning to question these ancient ideas. Using microscopes, some scientists noted that structures present in adult organisms were also present in their embryos. They hypothesized that embryos were pre-formed, miniature versions of their adult selves with pre-determined anatomy and behavior. Some scientists held that the pre-formed embryo was contained in the mother's egg; others that it was in the father's sperm. This family of hypotheses came to be known as preformationism.

Preformationism directly influenced ideas about heredity and human nature. Several scientists suggested that all humans had been contained, unchanged and pre-formed, in the eggs of Eve. This new science was even used to bolster religious doctrine. Jan Swammerdam, an entomologist and one of the founders of preformationism, wrote, "Thus original sin is explained, for all men were contained in the organs of Adam and Eve."

Preformationism remained the dominant theory of generation for most of the eighteenth century, but gradually, scientific thought shifted and new discoveries were made, including cell theory and modern genetics. Conrad Waddington, the biologist who coined the term epigenetics from the root word epigenesis, noted that both epigenesis and preformation are involved in embryonic development. Modern epigenetics thus builds on these two strains of thought to consider the interaction between that which is fixed and that which is fluid in our everyday lives.



Figures of homunculi in semen from *Istoria della generazione dell'uomo e degli animali* by A. Vallisneri (Venice, 1721). Image courtesy Wellcome Library, London.

"Thus original sin is explained, for all men were contained in the organs of Adam and Eve."

Jan Swammerdam

"We know that a fertilized egg contains some preformed elements—namely, the genes and a certain number of different regions of cytoplasm—and we know that during development these interact in epigenetic processes to produce final adult characters and features that are not individually represented in the egg."

Conrad Waddington

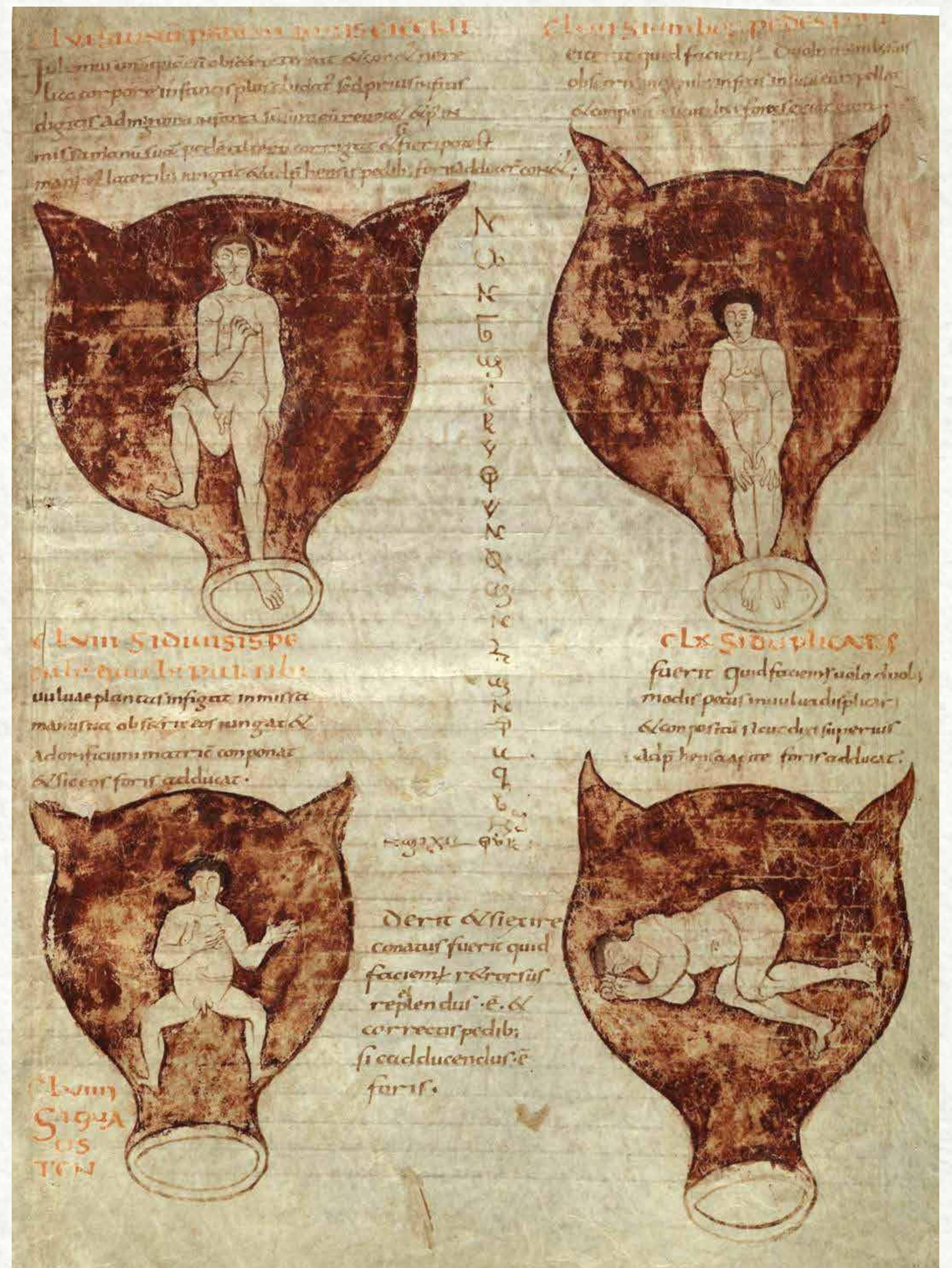
The Power of the Maternal Mind

Aristotle stressed the importance of the environment in utero for shaping the ideal offspring. If the mother provided a perfect environment for the embryo, Aristotle claimed the child would be male and resemble his father. Boys who resembled their mothers and females resembling either parent were the results of defects in the maternal environment.

Ancient and medieval physicians came up with various techniques and preparations for making sure the uterine environment was as hospitable as possible. The most powerful pregnancy aid, however, was the mind. Soranus of Ephesus, an authority on gynecology of the first and second century AD, thought that a pregnant woman's thoughts and experiences could shape her fetus. Soranus recounts a story of an ugly man and his plain wife, who gazed at an idealized statue as each of their children was conceived. Their offspring, according to Soranus, turned out to be beautiful. The message was clear: mothers-to-be were to expose themselves to attributes they wanted their child to possess in order to transmit them to their offspring.

This idea of a mother's mind affecting her children was not limited to the ancient world. Over a thousand years after Soranus, Aristoteles Master-Piece, an early obstetrical manual published in the sixteenth century, claimed, "though a Woman be in unlawful Copulation, yet if fear or any thing else causes her to fix her mind upon her Husband, the Child will resemble him, tho' he never got it." Rene Descartes, writing in 1630, referred to birthmarks as "marks that are impressed on children by the imagination of the mother."

Although we no longer think that having disturbing thoughts during pregnancy can alter the appearance of a fetus, researchers have found that a pregnant woman's emotions can affect her unborn child. Rachel Yehuda, a professor of psychiatry and neuroscience at Mount Sinai Medical Center in New York, conducted a longitudinal study of pregnant survivors of the 9/11 attacks in New York. Her research revealed that pregnant women who developed post-traumatic stress disorder (PTSD) in their second or third trimester had abnormally low levels of cortisol. A year later, their babies did too, and they were more likely than other babies to be distressed by new stimuli.



Fetal positions in womb, illustration to Soranus, Gynaecia (Manuscript: Brussels, Bibliothèque Royale, ms. 3701-15, fol. 58r), 11th century. Image courtesy Wikimedia Foundation.

"...the traces of these ideas travel through the arteries towards the heart, and thus ray out in all the blood; and... they can sometimes be determined by some of the mother's actions, and be imprinted on the members of the child who is forming in her womb."

Rene Descartes

Care and Feeding of Children

Ask any new parent: there are as many opinions on how to raise children as there are people. What children should eat, where they should sleep, and how they should be educated have been the subjects of debate for centuries.

John Locke and Jean Jacques Rousseau, two philosophers of the eighteenth century, entered into this argument on opposing sides. Locke stressed the influence of environment on child development. He famously described a child's mind as “white Paper, devoid of all Characters,” allowing a few innate tendencies but, for the most part, “Wax, to be moulded and fashioned as one pleases.”

Rousseau, on the other hand, thought children were born with natural inclinations which are inherently good. Rousseau refuted the idea of original sin and denied that children should be shaped according to societal norms. He was among the first to recognize that children are not miniature adults, but are instead at different stages of development. His philosophy incorporates both preformation and epigenesis: the child is born with a set of fixed characteristics, unique to himself, but the environment in which he develops is vitally important. One of Rousseau's legacies was an exhortation that mothers should breastfeed their own children rather than hiring a wet nurse - not for nutritional reasons, but to strengthen the natural attachment between mother and child. Scientists have explored the role of breastfeeding and mother-child bonding in child development ever since.

Epigenetics researchers continue to study the effects of early childhood experiences on adulthood, particularly the relationship between parent and child. Studies on rats have shown that those with attentive mothers have epigenetic markers that allow them to handle stress better as adults. Similarly, changes in a gene that plays a role in the body's response to stress have been observed in the adult victims of child abuse.



Maternal Instruction, from Godey's Magazine (1845). Image courtesy Special Collections and Rare Books, University of Missouri Libraries.

“...When mothers deign to nurse their own children, then will be a reform in morals; natural feeling will revive in every heart; there will be no lack of citizens for the state; this first step by itself will restore mutual affection.”

Jean Jacques Rousseau