Teaching Human Dignity

Maternal-Child Bond in Utero and in the "Fourth Trimester"

AN EXPERT GUIDE BY KRISTIN M. COLLIER, MD FACP

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The Maternal-Child Bond: Why is it Important to Understand?

The maternal-child bond refers to the biochemical, physical and emotional bond that exists between a mother and her prenatal and postnatal child in the "four" trimesters of pregnancy. Modern scientific and medical advances have given us a new understanding of the wondrous and awe-inspiring miracle that is the relationship between the mother and her child. Although much has been written about the bond between a mother and her child in childhood (especially in parenting books), there has been much less emphasis on the bond that exists between the mother and her child before the baby is even born. Scientists now have a greater understanding of this bond because of the development of prenatal ultrasound and advances in knowledge of the biochemical nature of both the mother and child as they relate to one another. Science has given us a window into the world of the uterus, a previously mysterious and unknown place. This window, however, should be understood and interpreted within the larger context of the miracle of the mother and child relationship and how it serves to reveal God's glorious design and handiwork.

The Placenta as a Fetomaternal Organ

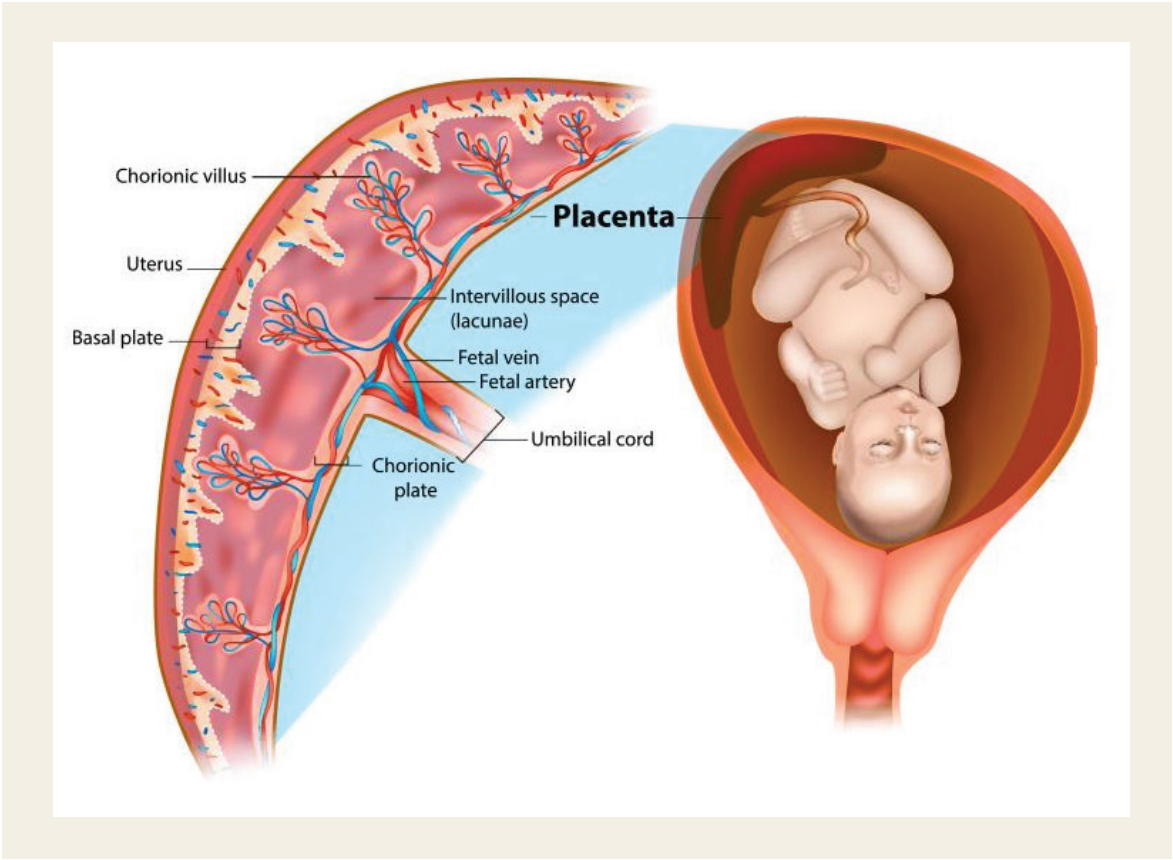
Mother and child start to work cooperatively right from conception. Their first act of cooperation is the building of the placenta, a flattened disk-shaped organ in the uterus of the pregnant mother that, through the umbilical cord, nourishes and maintains the prenatal child. Placenta is derived from the Latin word for cake because of its flat, "pancake" like appearance. It weighs approximately one pound and is attached to the mother along the wall of the uterus and to the prenatal child through the umbilical cord. The umbilical cord contains three vessels – two umbilical arteries and one umbilical vein and is usually about two feet long.

The placenta is the only purposely transient, or non-permanent, organ, and the only organ that is created in cooperation by two people: mother and baby. Because it is made by both the mother and baby, it is considered a fetomaternal organ. The placenta provides a biochemical interface between the distinct physiology of the prenatal child and her mother. In fact, it is the only organ that performs the work of

multiple organs and systems, acting as the baby's lungs and kidneys, as well as managing metabolic, thermo-regulatory, endocrine and immune functions.

In the placenta, the mother's red blood cells leave the confines of her arteries and float in a "pool" (formally known as the intervillous space) above the basal plate, which is the bottom boundary of the placenta. Loose floating red blood cells are incredibly uncommon. In traditional circulation, red blood cells are always housed within a vessel. The baby's umbilical cord comes down towards the placenta and creates what is known as the chorionic plate, which is the other half of the placenta. Trophoblast cells from the baby create protrusions into the "pool-like" space. This allows baby's vessels, found within the protrusions, to interface with the pool of red blood cells so that diffusion can occur between the red blood cells and the baby's vessels.

This complex interplay between the mother and baby allows the placenta to function as many of the baby's organs. The baby, because she is housed in amniotic fluid, cannot breathe ambient air but still needs oxygen. She also produces waste like carbon dioxide but cannot get rid of it by breathing out air. The baby still needs nutrients to grow even though she can't eat. All of these functions are facilitated through the placenta, which allows for gas exchange (oxygen and carbon dioxide) as well as nutrient exchange. While in utero, the prenatal child's temperature is also entirely maternal dependent. Heat is transferred to



Sakura, Placental structure and circulation, illustration, Shutterstock, https://www.shutterstock.com/image-vector/placental-structure-circulation-1277954032.

the prenatal child via the placenta and the uterus. In addition to these functions, the placenta has important immune function. For example, immunoglobulin G, or IgG, provides long-lasting immunity and crosses the placenta to provide immunity for the baby against infections. The placenta also makes several grams of protein (the building block of life) a day, and synthesizes cholesterol. Additionally, the placenta makes several hormones, including human chorionic gonadotropin, or HCG, which is detected on a positive pregnancy test and helps sustain early pregnancy, estrogen, which helps the uterus grow, and progesterone, which has an immune-suppressive action that keeps the mother's body from attacking the baby who is "other" to the mom. In fact, the placenta and uterus is an immune-privileged site that allows the baby to grow and develop.

> *"The placenta is arguably one of the most important organs in the body."* [1]

Historically, the placenta has been called the "afterbirth" as it is delivered after the baby and has long been considered nothing more than an afterthought. This, however, is changing. As part of the Eunice Kennedy Shriver National Institute of Child Health and Human Development arm of the National Institute of Health (NIH), "The Human Placenta Project," aims to better understand this important organ and to date, has granted more than fifty million dollars in research funding to study the placenta. As the NIH website says, "The placenta is arguably one of the most important organs in the body."[1]

Fetomaternal Microchimerism

In addition to the creation of the placenta, the interconnectedness between the prenatal child and her mother is intimate and far more profound than previously believed. We now know that genetic material from the prenatal child can cross through the placenta and can be found in her mother's circulation. In fact, this is the DNA that is analyzed in some of the prenatal screening tests that look for chromosomal abnormalities. However, the interaction at the level of genetic material between mother and prenatal child goes far beyond that of a transient crossing of genetic material into maternal circulation. It extends to a community of cooperation at the cellular level in what is called microchimerism.

The chimera in Greek mythology is the fire breathing creature that is made of three distinct creatures – a lion's head, a goat's body and a serpent's tail. In science, microchimerism is the presence of a small population of genetically distinct and separately derived cells within an individual. During pregnancy, the growing baby sends some of her cells across the placenta into her mother. These cells migrate to various sites of maternal tissue, integrate within the tissue, and assume the function of the surrounding tissue. The presence of fetal cells in maternal tissue is known as fetomaternal microchimerism, and science is just beginning to understand this phenomenon.

[1] "Human Placenta Project" Eunice Kennedy Shriver National Institute of Child Health and Human Development, accessed June 3, 2020, https://www.nichd.nih.gov/research/supported/HPP/default#:~:text=The%20placenta%20is%20arguably%20one,of%20both%20mother%20and%20child

> *It is clear, though, that the discovery of microchimerism challenges our longstanding conception of human beings as singular autonomous individuals.*[2, 3]

Microchimeric cells have been found in various maternal tissues and organs, such as the breast, bone marrow, skin, liver, and brain. Early and late effects of these cells have been hypothesized. Some of these cells appear to target sites of injury and may help mother heal after delivery by integrating into the Cesarean section wound and helping to produce collagen. Fetal cells may be involved in the process of lactation by signaling the mother's body to make milk. Others have been thought to help protect a mother against breast cancer later in life. Fetomaternal microchimerism likely involves negotiation and cooperation between mother and baby at the cellular level. Researchers are still in the early stages of attempting to understand the full function of these cells, but some models suggest that these cells can continue to aid the mother years after her baby is born and may even influence spacing of future siblings. There is also increasing evidence that fetomaternal microchimerism persists throughout life in many childbearing women. The full significance of fetomaternal microchimerism remains unclear, and in some studies, the cells have been linked to higher rates of diseases. It is clear, though, that the discovery of microchimerism challenges our longstanding conception of human beings as singular autonomous individuals.[2, 3]

Jacopo Ligozzi, A chimera, 1590-1610, drawing, 323 x 424 mm, Museo del Prado, Madrid, https://commons.wikimedia.org/wiki/File:Ligozzi_(Una_quimera).jpg.

[2] Melissa Lee Phillips, "Bearing Sons Can Alter Your Mind," Science, September 26, 2012, https://www.sciencemag.org/news/2012/09/bearing-sons-can-alter-your-mind.

[3] Robert Martone, "Scientists Discover Children's Cells Living in Mothers' Brains," *Scientific American*, December 4, 2012, https://www.scientificamerican.com/article/scientists-discover-childrens-cells-living-in-mothers-brain/.

Cellular microchimerism is not a unidirectional phenomenon. Rather the exchange of cells between mother and child is bidirectional. Male cells, for example, may occur in the blood of as many as 8-10% of healthy women who have no sons and no reported history of abortion or pregnancy loss.[4] This may be the result of a phenomenon called 'the vanishing male twin' or the result of microchimeric bidirectionality occurring over the course of multiple pregnancies. Vanishing twin syndrome refers to the condition in which one twin dies and is 'absorbed' by the other or by the mother or the placenta. It is thought to occur in anywhere from 20-30% of pregnancies with multiple babies. Cells that entered maternal circulation from a previous pregnancy with a male child may cross back over through the placenta during a subsequent pregnancy with a female child. In the case of identical twins, cells are also exchanged across the shared placenta between twins. Inherent in the process of development of human beings in utero is an interconnectedness at the cellular level. This interconnectedness is an example of active cooperation; it is radical mutuality at the cellular level. Even mothers who have lost children, either prenatal or postnatal, are still very much connected with their children as they carry their child's cells and DNA.

Many of us are interconnected at the cellular level-carrying the remnants of other human beings in our bodies. What is truly amazing is that these cells are not inert. It would be one thing to have the cells from another person in your body and for them to do nothing. But it is another thing entirely that these cells become integrated into maternal tissue and actively work in ways that we are just beginning to understand. This is radical mutuality at the cellular level.

"Many of us are interconnected at the cellular level-carrying the remnants of other human beings in our bodies."

Connection Through Voice

Research not only shows a high level of cooperation and a radical mutuality at the cellular level between mother and baby, but it also reveals the immense importance of a mother's voice. Not only is a mother's voice recognizable to her unborn child, and even preferred in utero, but that the mother's voice has the ability to affect her child's brain structure, influence her child's heart rate and respiration, and is likely a key factor in her child's development of language. Research[5] shows that by seven or eight months in utero, a baby's heart rate will slow down whenever mom is speaking, indicating that her voice is quite calming for the baby. In addition, the mother's voice impacts the size of her child's brain. In one study of premature babies, mothers' voices were recorded singing and reading. These recordings were played for hours a day to the intervention group of babies, while the control group received standard care. Babies who were exposed to their mother's voices had significantly thicker auditory cortices than those in the control group.[6] Another study showed that preterm infants had fewer episodes of slowed heart rate and altered respiration when they

[4] Gavin S. Dawe et al., "Cell Migration from Baby to Mother," *Cell Adhesion & Migration* 1, no. 1 (January-March 2007): 19-27.

[5] Laura Flynn Mccarthy, "What Babies Learn in the Womb," *Parenting*, accessed June 2, 2020, https://www.parenting.com/baby/what-babies-learn-in-the-womb/.

[6] Alexandra R. Webb et al., "Mother's Voice and Heartbeat Sounds Elicit Auditory Plasticity in the Human Brain Before Full Gestation," *PNAS* 112, no. 10 (March 10, 2015): 3152-3157, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4364233/pdf/pnas.201414924.pdf.

heard recordings of their mother's voice as compared to listening to regular ambient sounds.[7] A mother's voice not only is preferred by her baby above all other voices, but is likely instrumental in how a baby learns language. In one study, when a preterm baby heard her mother's voice, not only did the area of the brain responsible for recognition activate but so did the area responsible for language processing. When the babies were exposed to another female voice, only the area responsible for speech recognition activated.[8] This suggests that through the power of her voice, a mother is the primary initiator of language in her child. We can infer from these studies with preterm infants that this connection through voice is also occurring in utero. We are just beginning to understand the physiological and biochemical bond between mom and baby, but the fact that mothers' voices affect the size of their children's brains and the physiologic functions of breathing or heart rate, points to the beauty of how we all need and benefit from one other in a way that complements our underlying biology and speaks to a wondrous design that works best in relationship.

Fourth Trimester

The fetal-maternal bond developed between mother and baby in utero continues after birth. The fourth trimester is a term used to describe the period from the moment a baby is born until she is three months old. This is a time of great change and development for the newborn as she adjusts to her new world outside of the uterus. One of the most intimate ways in which mother and baby interact in the postpartum period is through breastfeeding. Lactation and breastfeeding provide a unique opportunity for bonding between mother and child and have special health benefits for mom and baby, especially in the important fourth trimester. Babies in the fourth trimester are at increased risk of infection. They are considered uniquely immunocompromised (similar to elderly patients) because of their relatively weak immune system. Breastfeeding not only provides a unique opportunity for mother-child bonding, but breast milk helps the baby by delivering immunoglobulin (antibodies) from the mom to the baby in order to help protect the baby from various types of infections. Breastfeeding has been shown to protect babies from necrotizing enterocolitis (NEC), perhaps through the beneficial effects of the microbiota of the breast milk.[9] It is also believed to reduce the risk of sudden infant death syndrome (SIDS), and may help reduce the risk of chronic disease in both mom and baby, such as childhood obesity, diabetes, and asthma in the child and breast and ovarian cancer in the mother. Breastfeeding appears to have some direct neurobehavioral benefits, such as increased cognitive ability and possibly mental health, although these outcomes may be more related to skin-to-skin contact than the human milk itself. This points again to a relational biology in which physical contact through relationship facilitates benefits for the brain of the baby. In addition, early skin-to-skin contact has been shown to increase blood sugar levels in the baby in a

[7] Laura Doheny et al., "Exposure to Biological Maternal Sounds Improves Cardiorespiratory Regulation in Extremely Preterm Infants," *Journal of Maternal-Fetal & Neonatal Medicine* 25, no. 9 (September 2012): 1591-1594, https://doi.org/10.3109/14767058.2011.648237.
[8] Maude Beauchemin, "Mother and Stranger: An Electrophysiological Study of Voice Processing in Newborns," *Cerebral Cortex* 21, no. 8 (August 2011): 1705-1711, https://doi.org/10.1093/cercor/bhq242.
[9] Necrotizing enterocolitis is a disease that affects the intestines where the wall of the intestine is invaded by bacteria which can cause infection and can lead to the destruction of the bowel wall itself. It occurs mostly in premature infants.

helpful manner, reduce infant crying, and promote cardiorespiratory stability.[10] It also helps reinforce and establish lactation to further promote breastfeeding. There also appears to be a pain reducing, or analgesic, effect associated with breastfeeding which may be due to the maternal-baby bonding that occurs during this process. In fact, breastfed infants experience less stress during painful procedures than formula fed infants.[11] Through the relational act of breastfeeding both mother and child benefit in ways we are just beginning to comprehend.

Conclusion

Pregnancy is a marvelous cooperative venture between mother and child that starts shortly after conception and continues post-partum. The existence of the placenta and fetomaternal microchimerism provide glimpses into this cooperation and an interconnectedness that exists at both a macro- and micro- level between mother and child in the larger relational biology of mankind. Their symbiosis serves as a beautiful example of God's relational creation in a way that speaks to interconnectedness, mystery and beauty.

[10] Moore ER, Anderson GC, Bergman N, Dowswell T. Early skin-to-skin contact for mothers and their healthy newborn infants. Cochrane Database Syst Rev 2012; :CD003519. (Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3979156/pdf/emss-57256.pdf).
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TERMINOLOGY

1 **Blastocyst**

A structure formed in the early development of mammals. It possesses an inner cell mass which subsequently forms the embryo.

2 **Embryo**

An unborn or unhatched offspring in the process of development, in particular a human offspring during the period from approximately the second to the eighth week after fertilization.

3 **Estrogen**

The primary female sex hormone responsible for the development and regulation of the female reproductive system and secondary sex characteristics.

4 **Fetal**

Relating to fetus.

5 **Fetus**

An unborn offspring of a mammal, in particular an unborn human baby more than eight weeks after conception.

6 **Microchimerism**

The presence of a small population of genetically distinct and separately derived cells within an individual.

7 **Oxytocin**

A hormone released by the pituitary gland that causes increased contraction of the uterus during labor and stimulates the ejection of milk into the ducts of the breasts.

8 **Placenta**

A flattened disk-shaped organ in the uterus of certain pregnant mammals, nourishing and maintaining the fetus through the umbilical cord.

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9 **Progesterone**

A sex hormone involved in the menstrual cycle, pregnancy and embryogenesis.

10 **The "Fourth" Trimester**

Time period that starts from the moment the baby is born and lasts until the baby is three months old. This is a period of great change and development in the newborn, as she adjusts to her new world outside of the uterus.

11 **Trimester**

Pregnancy is typically broken into three periods, or trimesters, each of about three months' duration. Each trimester is defined as 14 weeks, for a total duration of 42 weeks, although the average duration of pregnancy is 40 weeks.

12 **Trophoblast**

A layer of tissue on the outside of the blastocyst, supplying the embryo with nourishment and later forming the major part of the placenta.

13 **Uterus**

The organ in the lower body of a woman or female mammal where offspring gestate before birth. It is also known as the "womb."

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