

Further Development 14.4: The placenta and the integration of mother and fetus

Several investigators (Kingma 2018, 2019; Nuño de la Rosa et al. 2021; Meincke 2021) have concluded that neither the mother nor the fetus has separately delineated anatomies, immune systems, or physiologies. They offer a new perspective on pregnancy, claiming that neither the mother nor the fetus is a traditional biological “individual.” Rather, they propose that we view the pregnant mammal as a “gravida,” a transient form of the life cycle where the embryonic parts change the adult female as the adult female changes the embryo. Together, they co-produce the offspring and the mother. Indeed, physicians often describe the gravida as a “maternal-fetal unit,” needing specialized care. The mother (or the uterus) is certainly not a mere container that pre-exists to nourish and sustain the embryo growing within her. Interestingly, the localized inflammatory immune response that initiates pregnancy is also used to end pregnancy and initiate labor.

The traditional way of representing a uterus in Western culture was to see it as a container in which the fetus resides. This fetal container model of pregnancy contends that the fetus is inside, but not part of, the pregnant woman. The uterus is just a vessel containing the fetus. For example, Smith and Brogaard (2003, p. 74) write that the fetus is inside a woman in the way “a tub of yogurt is inside your refrigerator.” Oderberg (2008, p. 266) also writes that the embryo is “an organizational unity that is not a part of its host.”

The fetal containment model is not so much demonstrated as assumed. Historically, it is the model of a seed planted in soil. The soil nourishes and sustains the seed, but the soil and the seed are always separate entities (Baron 2019). One argument that has been used (Smith and Brogaard 2003) is a topological argument that the embryo/fetus, although within the external physical boundaries of the gravida (the pregnant person), is not a part of that organism because it is not topologically connected with it. Their main argument is that the embryo or fetus has a ‘complete, connected external boundary’ (p. 47) that it does not share with the gravida.

Kingma (2019) notes that the fetal container view is heavily promoted by the dominant representation of human pregnancy that pervades contemporary Western culture. This has certainly been part of the photographic tradition that abstracts the fetus from the mother, uterus, and umbilical cord (Howes-Mishel and Gilbert 2014). Much of the literature for restricting abortion has also assumed the fetal container model (Kingma 2018, 2019; Baron 2019) Thomson (1971) famously saw pregnancy as if one were to be hooked up to a critically ill patient who needed your body to dialyze his kidneys for nine months. Thus pregnancy was the use of one's body by a separate individual rather than the incorporation of two bodies into one.

The normalization of the fetal container model is perhaps most evident in discussions of surrogacy, which epitomize the view of pregnancy as a 'tenant-niche relation. Here, we find descriptions of pregnant women as 'bearers', 'containers', 'incubators', 'hatcheries', 'plumbing', 'rented property', or 'alternative reproductive vehicles. Surrogate mothers do not have a child, but merely 'utilize' their bodies to deliver a service. The fetal container model is crucial in enabling the claim that the 'biological parents' of a child are the genetic parents, denying the significance of gestation and harking back to a flowerpot view of pregnancy: this time, the fully-formed homunculus is replaced by an embryo belonging to the commissioning parents, which the surrogate mother will simply incubate until it is ready to be given back (Baron 2019).

The major alternative view is the "parthood model of pregnancy," according to which the fetus is a part of the pregnant woman (Kingma 2019, 2020). For instance, Iris Young describes the fetus as "part of me," while D. H. Mellor writes that "severing a newborn child's umbilical cord makes the child cease to be a part of its mother." Here, a fetus is part of being "a pregnant woman." Recent studies have provided evidence in favor of this "parthood model.

Anatomical continuity.

As made clear in the discussion of human embryology, the embryo/fetus produces cells that intermingle with those of the uterus. The placenta is an organ that is made from both trophoblast tissue of the embryo and uterine tissue of the mother. The cells interact to make this organ, and there is no clear anatomical line of separation between them.

For instance, if one looks at the boundary between fetus and mother as the boundary of the future baby's skin and esophagus, a boundary has to be drawn somewhere along the fetus's umbilical cord, roughly where that cord will be cut after birth, or perhaps even at the umbilicus, where the remainder of that cord will fall off about a week later. If one takes the "future baby plus placenta" view, one must trace a boundary at the maternal side of the placenta—perhaps at the rough locus of the placenta's future separation—to capture the whole placenta.

The existence of the umbilical cord means that the "future baby" fails to meet the conditions for being an autonomous tenant. This is summarized by Kingma (2020). The "Future Baby View" cannot withstand scientific scrutiny because (1) fetuses and pregnant organisms may have parts in common—namely, the arteries, veins, membranes, and glutinous tissue (Wharton's jelly) that form the umbilical cord as well as the blood that flows through them; (2) fetus and pregnant organism certainly share an external boundary, and (3) the fetus and pregnant organism are not separated by a cavity. On the "Future Baby Plus Placenta" view, one finds that one cannot find a separation to draw between the cells of maternal and fetal origin: (1) fetal cell lineages colonize the maternal spiral arteries such that maternal and fetal cells intermingle and directly border each other; (2) maternal blood, including maternal cells, permeates cavities and parts of the placenta created, surrounded, and maintained by embryonic cell lineages; and (3) in the anchoring villi, fetal mesenchyme and maternal connective tissue form one tissue that holds the placenta together. Fetal and maternal-derived tissue cannot be readily separated; there is no line here, let alone the sort of boundary—marked by physical discontinuity in tissue (Kingma 2020; Sato 2020).

One might try to locate the boundary at the place of future placental separation. This is known as Nitabuch's layer—an area of spongy tissue in the basal plate of the placenta. Later in the pregnancy, fibrous deposits start to appear at this locus. However, this is not a boundary between fetal and maternal tissue. Moreover, there is no boundary at this place until placental separation starts. There is no membrane nor any a physical discontinuity here that separates the pregnant woman from the placenta before the latter physically separates at birth. Rather, there is continuous connective tissue, especially in the anchoring villi where fetal and maternal mesenchyme cells connect. In addition, even if there were a boundary here, it would be traversed by vessels and canals through which blood flow. Thus, anatomically the fetus is part of the mother. It is not a tenant inside a vessel.

It might be argued that the fetus cannot be a part of the mother because it has a different genotype and that it was acquired, not developed like a kidney from the epiblast. However, within the past ten years, it has been discovered that over 50% of human cells are acquired microbes, each with its own genotype. As mentioned earlier, these microbes help form our bodies and they give our bodies some of our phenotype.

Birth is going from one symbiotic relationship (that with the mother) to another (that with the microbes) (McFall-Ngai et al 2012; Gilbert 2014 Takeshita 2017. The normal situation for animals is to share one's body with genetically different organisms (see Chapter 25). Pregnancy is the mammalian's new take on this model.

Physiology

One definition of an individual organism states mandates that its components share the a common physiological environment. Pepper and Herron 2008)make a strong case for such a view, and they claim it to be so even, as in the case of lichens, when the components are of different genetic origins. The pregnant woman (the gravida) and the fetus interact to make a common physiological environment , a qualification for being an organism . (Kingma (2019) extends this idea to pregnant woman. A pregnant woman's body interacts with the fetus just like her body organs interact with her kidneys, liver, and pancreas. The fetus, being nested

within the pregnant woman and connected to her by their shared circulatory systems, is subject to the diet, stress levels, and other factors influencing the pregnant woman's physiology. And the fetus, being connected to the woman, changes her physiology, as well, just as a well-functioning pancreas or ovary would.

The gravida has numerous additional changes in her physiology (Napso et al 2018). In this, the trophoblast, in particular, is important. In addition to its being a structural component of the embryo, it is an endocrine organ. The trophoblast from the embryo makes numerous hormones that are shared between gravida and fetus. These include human chorionic gonadotropin (hCG), human chorionic corticotropin (hCC), as well as several pro-opiomelanocortin-derived peptides, including β -lipotropin, β -endorphin, and α -melanocyte-stimulating hormone. As mentioned earlier, hCG is a hormone that stimulates the corpus luteum in the ovary to make progesterone during the first trimester. This progesterone is critical for limiting the immune response against the embryo and for making the uterine tissue pliable. During the third trimester, large quantities of placental lactogen are produced, a hormone thought to have a role as a regulator of lipid and carbohydrate metabolism in the mother. Human placental lactogen also makes the gravida body less sensitive to the effects of insulin, a hormone that moves glucose from the bloodstream into the cells. This also leaves more glucose available in the pregnant woman's bloodstream to nourish the fetus.

The fetus' state is regulated by, and within, the context of, the rest of the gravida, so that the entire entity can maintain its internal environment within the narrow range of parameters that are compatible with life. The fetus relies on the rest of the gravida for many of its important physiological functions, including the extraction of oxygen, digestion, temperature regulation, and waste disposal. And the gravida actively integrates the fetus into its metabolic system, making anatomical and metabolic accommodations to facilitate its continued presence, such as an increase in cardiac output.

Although one might object that the fetus and (other) parts of the gravida are not functionally integrated on the grounds that they sometimes compete for resources, such as calcium and iron, this is not a relevant argument. Muscles and gut compete for oxygen, brain and muscles

compete for sugars, and the bladder and sperm compete for the penile urethra (Kingma 2019).

As discussed in Napso et al (2018), alterations in the maternal cardiovascular system begin very early in gestation and ultimately lead to systemic vasodilation and increased blood perfusion of maternal organs, including the gravid uterus. Systemic vascular resistance is reduced by 25–30% and accompanied by a 40% increase in cardiac output during human pregnancy. Kidney blood flow and filtration rates are also increased. The renin-angiotensin-aldosterone system, which is a major determinant for sodium balance during gestation, is progressively upregulated toward term with associated plasma volume expansion. This rise in blood volume, which is required to cope with the oxygen requirements of the maternal organs and the conceptus growth, plateaus by the late gestation, resulting in an increase in total blood volume by approximately 30% at the end of pregnancy. There is also an increase in the numbers of red blood cells in the mother during pregnancy, due to proliferation of erythroid progenitors in the spleen.

Pulmonary function of the pregnant woman is also altered and encompasses changes in ventilation rates and blood gases. For instance, lung tidal volume and minute ventilation increases by 30–50%. As a result of increased oxygen consumption during hyperventilation, there is greater carbon dioxide production, which leads to chronic respiratory alkalosis that is compensated by an increased renal excretion of bicarbonate. Overall, these adaptations ensure the well-being of the mother, while also providing an adequate blood flow to the placenta for fetal nutrition, oxygenation and maturation.

The pregnant woman's physiology is definitely not separate from that of the fetus. The fetus is physiologically a part of the pregnant woman.

Immunology

One of the most startling abilities of the gravida is her accepting the embryo as part of herself. The embryo has proteins from the father's portion of the genome, and the pregnant

woman's immune system would be expected to recognize and destroy such cells. However, this is not what happens (Medawar 1953). Instead, mammals have evolved a mechanism to turning foes into friends, of transforming swords into plowshares. The fetus becomes part of the woman's body and is not destroyed¹.

Inflammation is an immune response against foreign entities, such as bacteria and viruses, wherein lymphocytes and macrophages enter an area of the body to destroy the invasive agents. When this happens, these immune cells also release a class of proteins (cytokines) that destroy tissues and their extracellular matrices (Birkedal-Hansen 1993). While this destruction might help the lymphocytes find and eliminate bacteria and viruses, it also breaks down normal tissues. Inflammation has classically been seen as one of the greatest threats to normal pregnancy, causing preterm labor and the death of the fetus (Romero et al 2014).

However, as mentioned in the text, new experiments (Mor et al 2011; Chavan et al 2017) have shown that such inflammation is critical in both the implantation of the embryo into the uterus and the eventual expulsion (parturition) of the embryo from the uterus during labor. Upon implanting, Therefore, the blastocyst initiates a modified inflammatory response, wherein the cytokines from the immune cells can remodel of the uterus to make it more receptive to receiving the embryo, but prevent continuation of the inflammatory response. Moreover, placental estrogen and progesterone contribute to the maternal tolerance of the fetus by modulating the proliferation and cytokine secretion of cytotoxic T cells while enhancing the suppressive function of suppressive, regulatory T-regulatory cells (Mao et al 2010; Robinson and Klein 2012; Lissauer et al 2015).

Finally, the integration of the fetus with the maternal immune system is seen in the development of the mother's breasts during the last trimester. The trophoblast portion of the placenta also synthesizes and secretes human placental lactogen, a hormone that works with

¹ One of the greatest changes in 21st century biology has been the recognition that defense is only a part of the immune system's functions. The major function of the immune system may be to distinguish beneficial symbionts from pathogenic organisms. It not only destroys or expels the pathogenic organisms, but it also welcomes and protects the beneficial symbionts, making them part of the body's systems of physiology, immunity, and development. This appears to be occurring for the embryo, as well (Tauber 2008, 2017 ; Pradeu 2012; Gilbert and Tauber 2016).

prolactin, progesterone, and estrogen to promote the growth of the mammary gland and the production of milk during the last months of pregnancy. These hormones stimulate the growth of the mammary glands and the differentiation of the of the lobular buds into milk-secreting lobules (Horseman 1999). The mammary glands are an immune organ as well as a nutritive organ, and mother's milk contains the mother's antibodies, lymphocytes, macrophages, and symbiotic bacteria that will provide passive immunity to the newborn and stimulate the production of the newborn's own immune system (Ruiz-Palacios et al 1990; Ardeshir et al 2014; Cabinian et al 2016; Hanson 2000; Laouar 2020). The mother's immune system allowed the embryo to implant, protected the fetus in utero, and stimulates immunity in the newborn.

Therefore, embryo and fetus are not merely residents of a uterine food court. The uterus is not a vessel that merely houses and feeds the embryo. Rather, the embryo and fetus are intimately united such that they become a single organism with the pregnant woman for this period of pregnancy. There is substantial evidence that the embryo/fetus cannot be separated from the gravida (Kingma 2019; 2020; Nuño de la Rosa et al 2021). The "pregnant woman" includes the fetus.

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