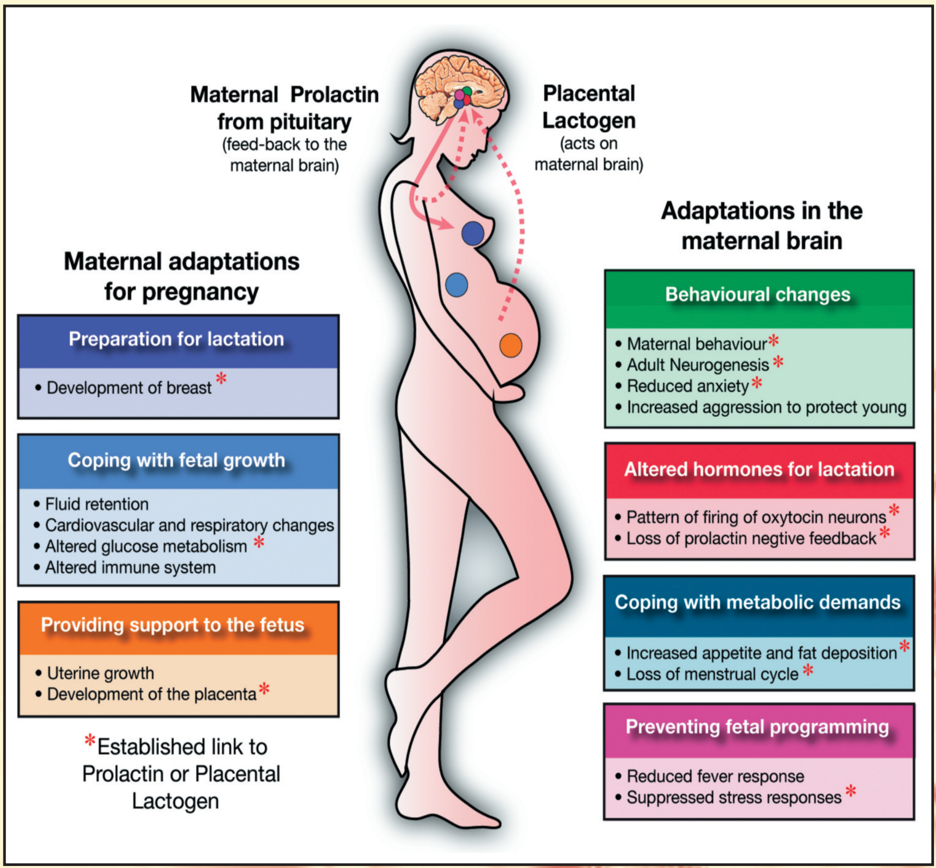
A Mother's Brain Knows

SUMMARY

Prolactin is a pregnancy hormone that is essential for development of the mammary gland for milk production. In addition, prolactin exerts important actions in the maternal brain, resulting in changes in maternal physiology and behaviour that help the mother cope with the new demands of pregnancy, childbirth and lactation. Hence, the same hormonal signal is used both by brain and body to recognise and adapt to these new physiological states.

Many changes must occur in the pregnant female to prepare her for the physical and physiological demands of becoming a mother (see figure). Some of the physical changes are obvious. The abdomen expands as the uterus grows and the placenta is established to allow for growth and nutrition of the developing fetus. The breasts get larger and change shape, as the fatty tissue is gradually replaced by glandular epithelial tissue that will produce milk.

But it doesn't stop there. Her brain is also undergoing a number of extraordinary modifications that will result in changes to her body functions. The control of her hormone secretion changes, such that the pattern of secretion is unique to the pregnant or lactating state. Her appetite increases, and she starts to eat more and gain weight. This is because milk production requires a lot of energy, and nature prepares the mother for this by encouraging fat deposition during pregnancy. Her reproductive cycle is stopped, again focusing energy on the present pregnancy rather than further ovulations. She also becomes less responsive to stressors in her environment, and no longer mounts a fever in response to infection. These changes protect the baby from being exposed to excessive stress hormones, or to excessive temperatures that might harm



Multiple actions of pituitary prolactin and the related placental lactogen in the maternal brain during pregnancy and lactation.

development. Remarkably, there is an increased production of new neurons in the maternal brain during pregnancy, and this contributes to the dramatic changes in mood and behavior that accompany pregnancy and childbirth. All of these changes require the brain to function differently in pregnancy compared to any other time, a type of neuronal plasticity that specifically adapts brain function for motherhood.

Role of prolactin

Unlike human mothers, who may have a urine test to determine whether they are pregnant, mothers of other animals do not have any external information, and yet undergo all of these changes in preparation for becoming a mother. Their brains are simply responding to the hormonal changes that are associated with ovulation, mating, implantation and pregnancy. The anterior pituitary hormone prolactin and the closely-related placental lactogens (pregnancy-specific hormones from the placenta) are emerging as important candidates for mediating adaptive changes in the maternal brain. Because of the unique situation of having both a maternal and placental source of hormone, prolactin-like hormones are present at high levels throughout pregnancy, birth and lactation.

"...prolactin emerges as an important candidate for mediating adaptive changes in the maternal brain."

These hormones are able to cross into the brain, and act on prolactin receptors that are widely distributed on key brain circuits. Prolactin stimulates the onset of maternal behavior after birth, and it is also involved in stimulating appetite during pregnancy, and facilitating some of the changes that occur in the stress axis. Elevated prolactin causes infertility, and thus may contribute to the suppression of ovulation during pregnancy and lactation. Prolactin is also specifically involved in stimulating production of new cells (neurogenesis) in the maternal brain, and this may promote appropriate changes in mood and maternal behavior postpartum.

Evolution of the maternal brain

From an evolutionary perspective, it is perhaps unsurprising that hormones that are required for milk production, such as prolactin, are also involved in mediating adaptive changes in the maternal brain. The evolution of lactation defined a new class of vertebrates, the mammals. Their reproductive strategy involved producing a nutritious secretion from an exocrine gland in the skin, and encouraging the new offspring to consume it. It allowed continued nurturing of the offspring even after its umbilical connection to the mother was severed at birth. Hence, the period of parental investment in their offspring was extended well beyond pregnancy, providing significant benefits including the opportunity for enhanced brain development in the offpsring. For this new strategy to succeed, however, required more than just milk production. It required the complementary changes in the mother to cope with the metabolic and social demands of being a parent, including complex behavioral changes. It seems logical that nature would use the same hormones that were required for milk production to signal the need for complementary adaptive changes in the brain.

Complications

The hormonal changes of pregnancy are required to induce both subtle and not-so-subtle changes in the function of the maternal brain. It goes without saying, therefore, that factors that influence hormone secretion during pregnancy will have consequences on the outcome of the pregnancy, either for the mother or the offspring, or both. Small changes, caused by stress or illness at an inappropriate time might have adverse effects that do not become apparent until some time later. For example, in mice, a decrease in neurogenesis in the maternal brain during early pregnancy causes postpartum anxiety and impaired maternal behavior some weeks later! Other diseases of pregnancy and postpartum, such as gestational diabetes, hypertension, postpartum depression, and failure to bond with the baby, might similarly have their origins in impaired neuroendocrine adaptation to the hormonal changes associated with pregnancy. All of us have mothers, and many of us will be mothers. It is important that we understand how hormones are influencing the brain, so that we can better identify causes of problems that might occur during pregnancy, and provide better therapies when such problems do arise.

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