Reproductive Physiology

Pregnancy and Lactation

Chapter 83

Response of the Mother’s Body to Pregnancy

Weight Gain in the Pregnant Woman

- The average weight gain during pregnancy is about 10 to 15 kg.
- Most of this gain occurring during the last two trimesters.
- Fetus 3.5 kg, amniotic fluid 1.5 kg, placenta, and fetal membranes.
- Uterus and breasts increase in size .
- Extra fluid in the blood and extracellular fluid.
- Fat accumulation.

The extra fluid is excreted in the urine during the first few days after birth—that is, after loss of the fluid-retaining hormones from the placenta.
During pregnancy, a woman often has a greatly increaseddesire for food, partly as a result of removal of food substratesfrom the mother's blood by the fetus and partly because of hormonal factors.
Without appropriate prenatal control of diet, the mother's weight gain can be as great as 75 pounds instead of the usual 25 to 35 pounds.

Metabolism During Pregnancy

- As a consequence of the increased secretion of many hormones during pregnancy, including **thyroxine**, **adrenocortical hormones**, and the **sex hormones**, the basal metabolic rate of the pregnant woman **increases about 15%** during the **latter half** of pregnancy.

- Extra load → **greater** amounts of energy for **muscle activity**.
- **Overheated sensation.**

Endocrine glands

- As a response to **increase basal metabolic rate** and **placental hormones.**
- The **anterior pituitary** gland of the mother **enlarges** at least **50%** during pregnancy
- Increases its production of **(ACTH), TSH, and prolactin**.
- **FSH and LH** are almost totally **suppressed** as a result of the inhibitory effects of estrogens and progesterone from the placenta.
- Increase glucocorticoid and aldosterone secretion.
- Increase thyroid gland size and T_4 production.

Endocrine glands-- Increased Parathyroid Gland Secretion

- The mother's parathyroid glands usually **enlarge** during pregnancy.
- Increase **calcium absorption** from the mother's **bones**, thereby maintaining normal calcium ion concentration.
- While the **fetus** removes calcium from maternal circulation to **ossify its own bones**.

- This secretion of parathyroid hormone is even **greater** during **lactation** because the growing baby requires many times more calcium than does the fetus.

Nutrition During Pregnancy

- Ordinarily, the mother does not absorb sufficient protein, calcium, phosphates, and iron from her diet during the last months of pregnancy to supply these extra needs of the fetus.

- However, in anticipation of these extra needs, the mother's body has already been storing these substances—some in the placenta, but most in the normal storage depots of the mother.

- Iron, vitamin D, folic acid, and vitamin K

**By far the greatest growth of the fetus occurs during the last trimester of pregnancy; its weight almost doubles during the last 2 months of pregnancy.

- Without sufficient iron in her food, a pregnant woman usually develops *hypochromic anemia*.
- Also, it is especially important that she receive vitamin D, because although the total quantity of calcium used by the fetus is small, calcium is normally poorly absorbed by the mother's gastrointestinal tract without vitamin D.
- Finally, shortly before birth of the baby, vitamin K is often added to the mother's diet so that the baby will have sufficient prothrombin to prevent hemorrhage,particularly brain hemorrhage, caused by the birth process.

Blood Flow Through the Placenta and Maternal Cardiac Output Increase During Pregnancy

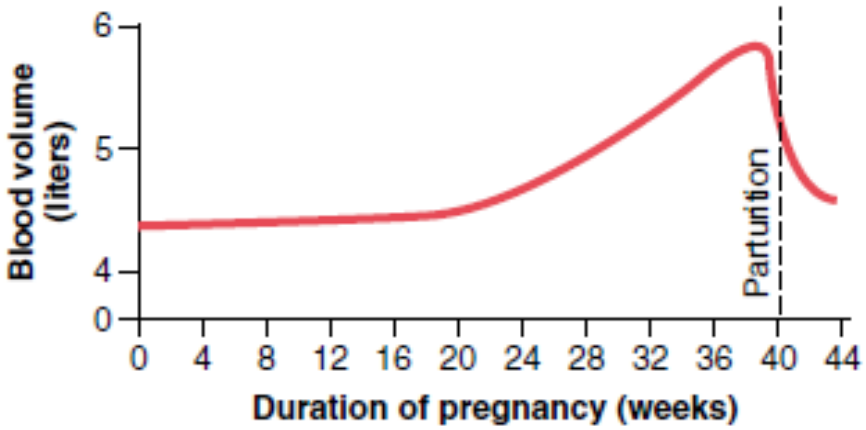
- ↑ Blood flow through the maternal circulation of the placenta
- ↑ Mother's metabolism
- ↑ Mother's cardiac output to 30% to 40% above normal by the 27th week of pregnancy

~625ml/min of blood into the placenta>>> increase cardiac ouput
for reasons unexplained, the cardiac output falls to only a little above normal during the last 8 weeks of pregnancy, despite the high uterine blood flow

Maternal Blood Volume Increases During Pregnancy

- The maternal blood volume shortly before term is about 30% above normal.
- The cause: aldosterone and estrogens
- Increased fluid retention by the kidneys.
- In addition, the bone marrow becomes increasingly active and produces extra red blood cells to go with the excess fluid volume.

Therefore, at the time of the birth of the baby, the mother has about 1 to 2 liters of extra blood in her circulatory system. Only about 350 ml is normally lost through bleeding during delivery of the baby, thereby allowing a considerable safety factor for the mother.



Maternal Respiration Increases During Pregnancy

- **Increased basal metabolic rate** + **greater size** → the total amount of **oxygen** used by the mother is about **20% above normal**
- These effects cause the mother's minute ventilation to increase.
- Pressing the diaphragm, **less space** → the **respiratory rate** is **increased** to maintain the extra ventilation.
- High levels of **progesterone** increases the **sensitivity** of the respiratory center to **carbon dioxide**

Maternal Kidney Function During Pregnancy

- Increased urination → because of increased fluid intake and increased load of excretory products.

- The renal tubules' reabsorptive capacity for sodium, chloride, and water is increased.
- The renal blood flow and glomerular filtration rate as a result of renal vasodilation (relaxin).

Labor

Increased Uterine Excitability Near Term

- (1) progressive hormonal changes that cause increased excitability of the uterine musculature.
- (2) progressive mechanical changes.

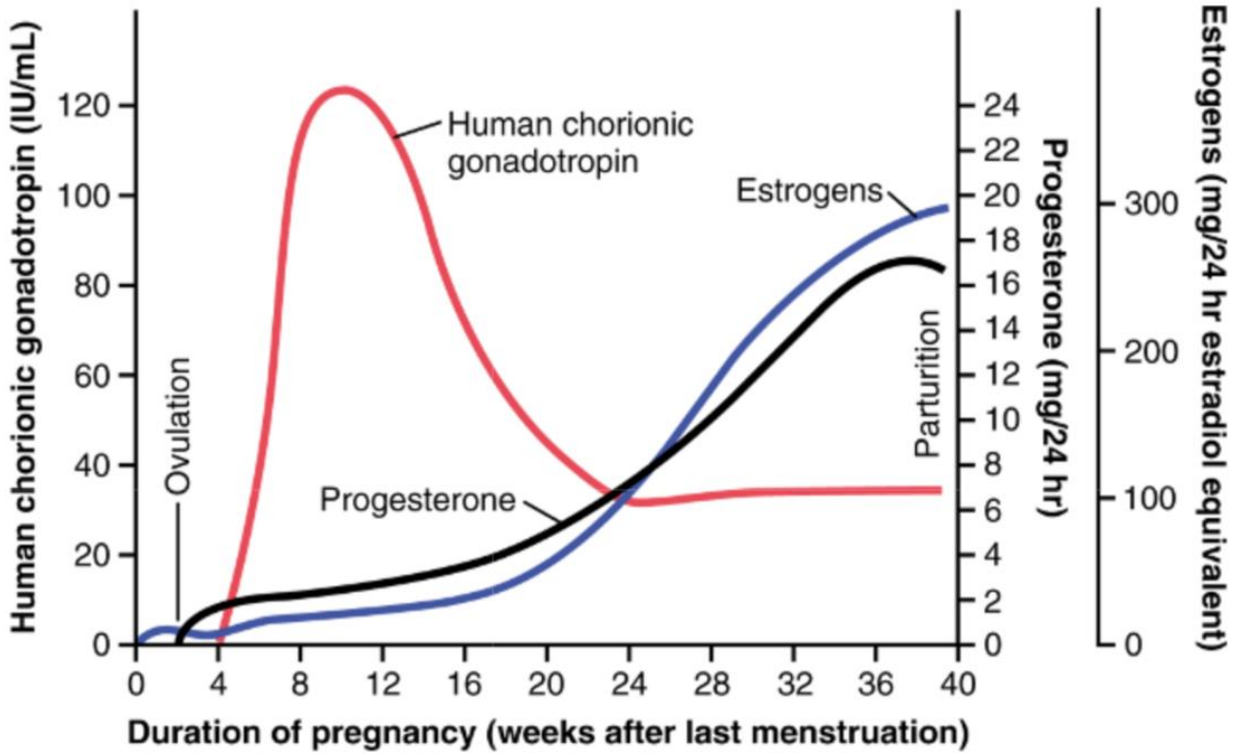
Parturition means birth of the baby. Toward the end of pregnancy, the uterus becomes progressively more excitable, until finally it develops such strong rhythmical contractions that the baby is expelled. The exact cause of the increased activity of the uterus is not known, but at least two major categories of effects lead up to the intense contractions.

Hormonal Factors That Increase Uterine Contractility

Increased Ratio of Estrogens to Progesterone

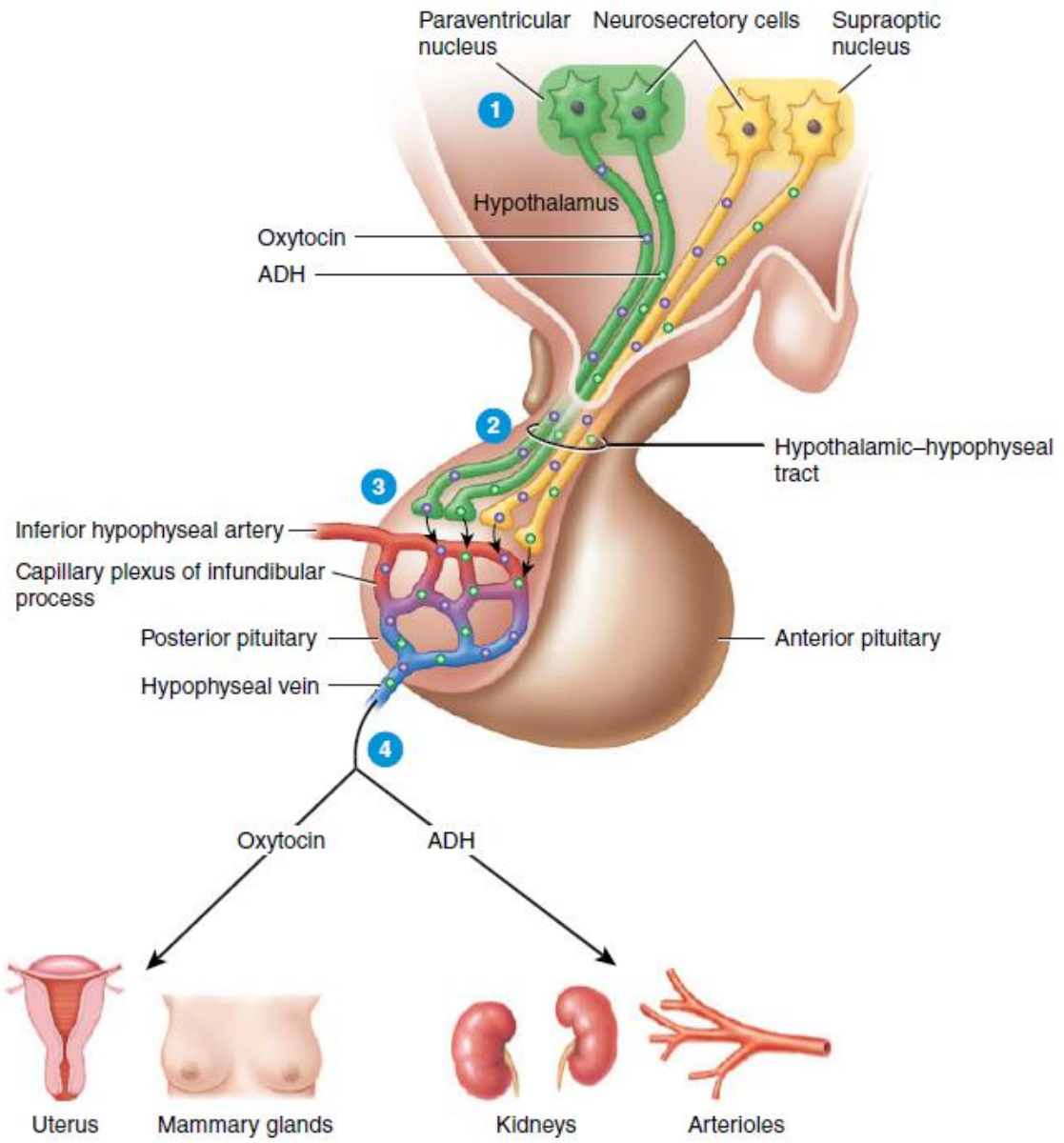
- The estrogen-to-progesterone ratio increases sufficiently toward the end of pregnancy (from week 28 onward) to be at least partly responsible for the increased contractility of the uterus.

** Estrogens increase the number of gap junctions between the adjacent uterine smooth muscle cells.



Oxytocin

- 1. The uterine muscle increases its oxytocin receptors during the latter few months of pregnancy.
- 2. Oxytocin secretion rate is increased at the time of labor.
- 3. Labor is prolonged in hypophysectomized animals.
- 4. Irritation or stretching of the cervix cause an increase in oxytocin secretion.



- Effect of Fetal Hormones on the Uterus
- The fetus's pituitary gland secretes increasing quantities of oxytocin, which might play a role in exciting the uterus. Also, the fetus's adrenal glands secrete large quantities of cortisol, another possible uterine stimulant. In addition, the fetal membranes release prostaglandins in high concentration at the time of labor. These prostaglandins, too, can increase the intensity of uterine contractions.

Mechanical Factors That Increase Uterine Contractility

Mechanical factors

- **Stretch of the Uterine Musculature**
- Stretching smooth muscles usually increases their contractility.

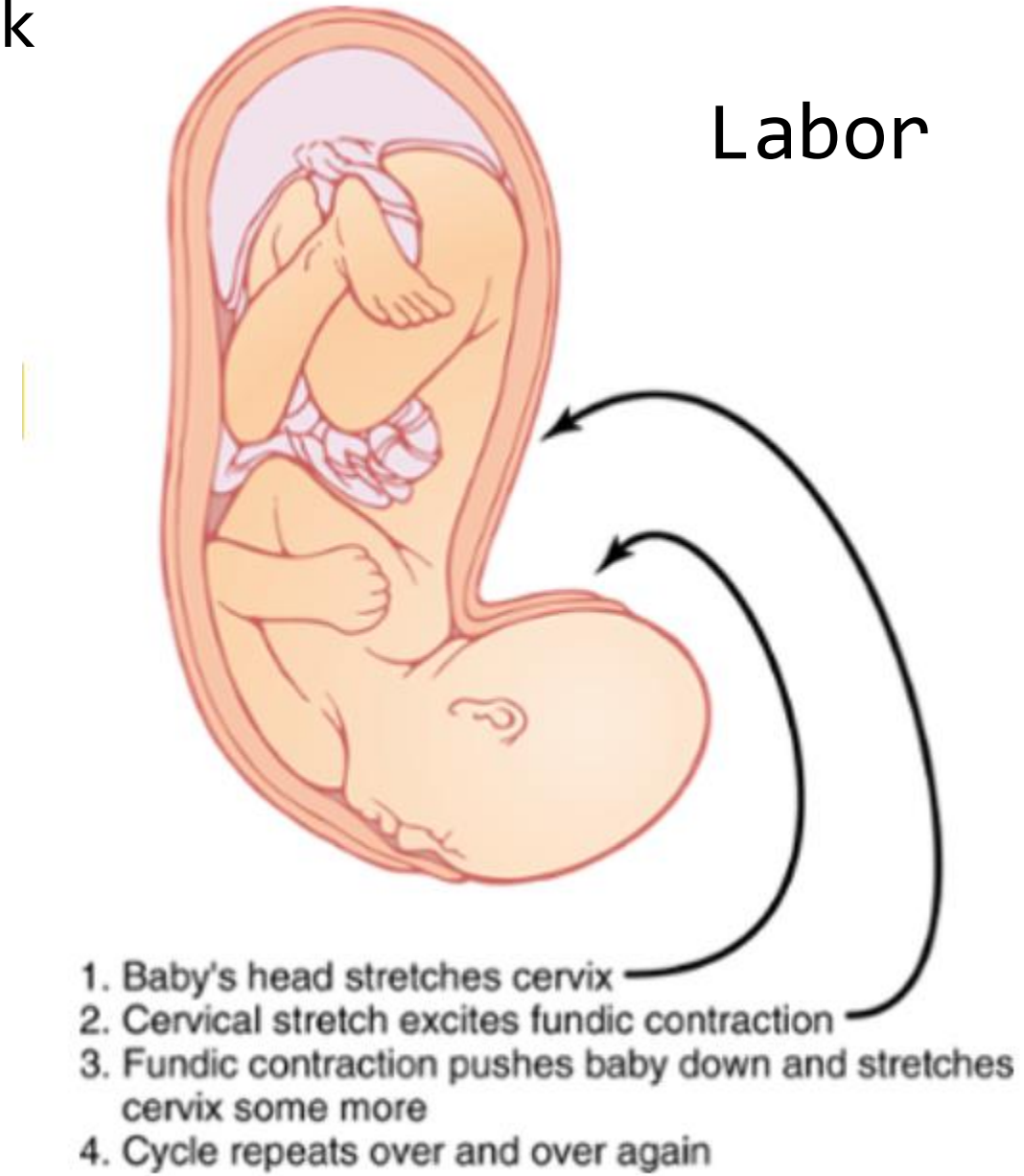
- **Stretch or Irritation of the Cervix**
- Obstetricians frequently induce labor by rupturing the membranes so the head of the baby stretches the cervix more forcefully.

** Note especially that twins are born, on average, 19 days earlier than a single child, which emphasizes the importance of mechanical stretch in eliciting uterine contractions
stretching or irritation of nerves in the cervix initiates reflexes to the body of the uterus,
OR result simply from myogenic transmission of signals from the cervix to the body of the uterus.

Onset of Labor—A Positive Feedback Mechanism for its Initiation

- The positive feedback theory suggests that **stretching** of the **cervix** by the **fetus's head** finally becomes **great enough** to elicit a strong reflex increase in **contractility of the uterine body**.
- This pushes the baby forward, which stretches the cervix more and initiates more **positive feedback** to the uterine body.
- The process repeats until the baby is expelled.

Labor



- **(1) Stretching of the cervix causes the entire body of the uterus to contract, and this contraction stretches the cervix even more because of the downward thrust of the baby's head.
- (2) Cervical stretching also causes the pituitary gland to secrete oxytocin, which is another means for increasing uterine contractility.

- **Remember that for a positive feedback to continue, each new cycle of the positive feedback must be stronger than the previous one. If at any time after labor starts some contractions fail to re-excite the uterus sufficiently, the positive feedback could go into a retrograde decline, and the labor contractions would fade away.

Abdominal Muscle Contractions During Labor

- Once uterine contractions become strong during labor → pain signals → elicit neurogenic reflexes → to the abdominal muscles → causing intense contractions.
- The abdominal contractions add greatly to the force that causes expulsion of the baby

Stages of Labor

- The first stage lasts from the onset of true labor to complete dilation of the cervix.
- The second stage spans from complete dilation of the cervix to the birth of the baby.
- The third stage lasts from the birth of the baby to delivery of the placenta.
- The fourth stage spans from delivery of the placenta to stabilization of the patient's condition, usually at about 6 hours postpartum.

- **It is fortunate that the contractions of labor occur intermittently, because strong contractions impede or sometimes even stop blood flow through the placenta and would cause death of the fetus if the contractions were continuous. Indeed, overuse of various uterine stimulants, such as oxytocin, can cause uterine spasm rather than rhythmic contractions and can lead to death of the fetus.

Separation and Delivery of the Placenta

- Separation of the placenta opens the placental sinuses and causes bleeding. (350 ml):
- Contraction of the uterus after delivery of the baby constricts the vessels that had previously supplied blood to the placenta. (8)
- Vasoconstrictor prostaglandins formed at the placental separation site.

- ** For 10 to 45 minutes after birth of the baby, the uterus continues to contract, which causes a shearing effect between the walls of the uterus and the placenta, thus separating the placenta from its implantation site.

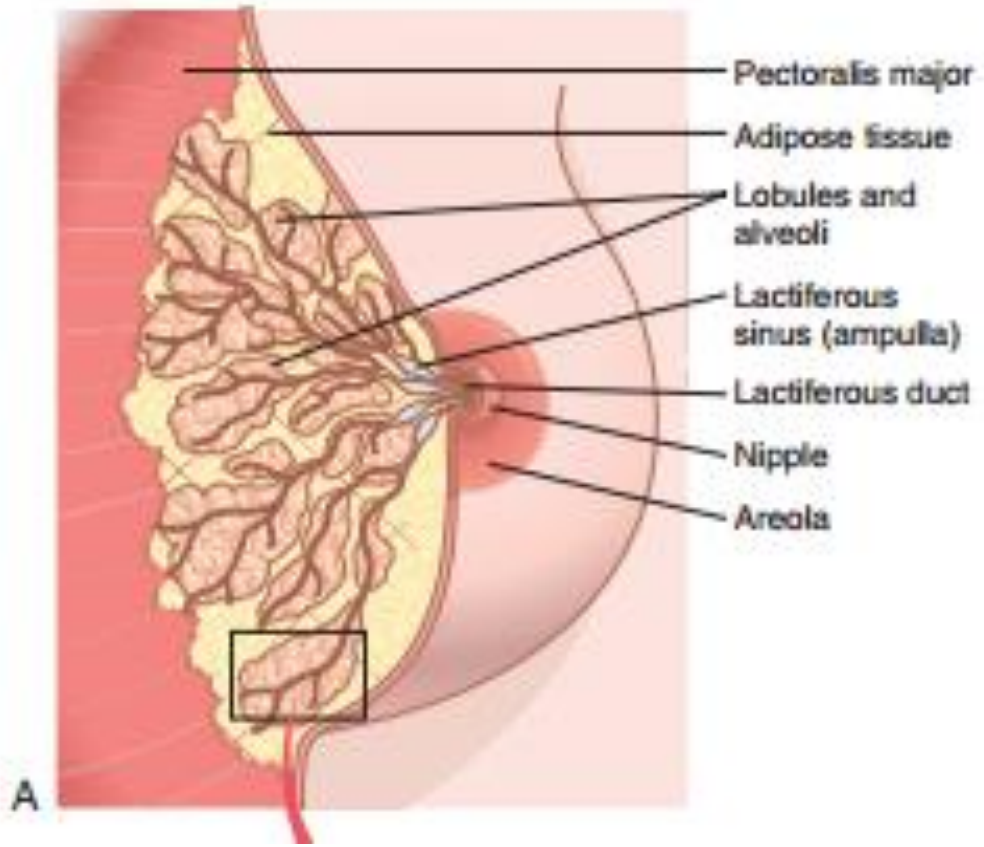
Labor PAIN

- In **early labor** is probably caused mainly by **hypoxia** of the uterine muscle resulting from compression of the blood vessels in the uterus.
- During the **second stage** of labor, when the fetus is being expelled through the birth canal, much more severe pain is caused by **cervical stretching**, **perineal stretching**, and **stretching or tearing of structures in the vaginal canal itself**.

Lactation

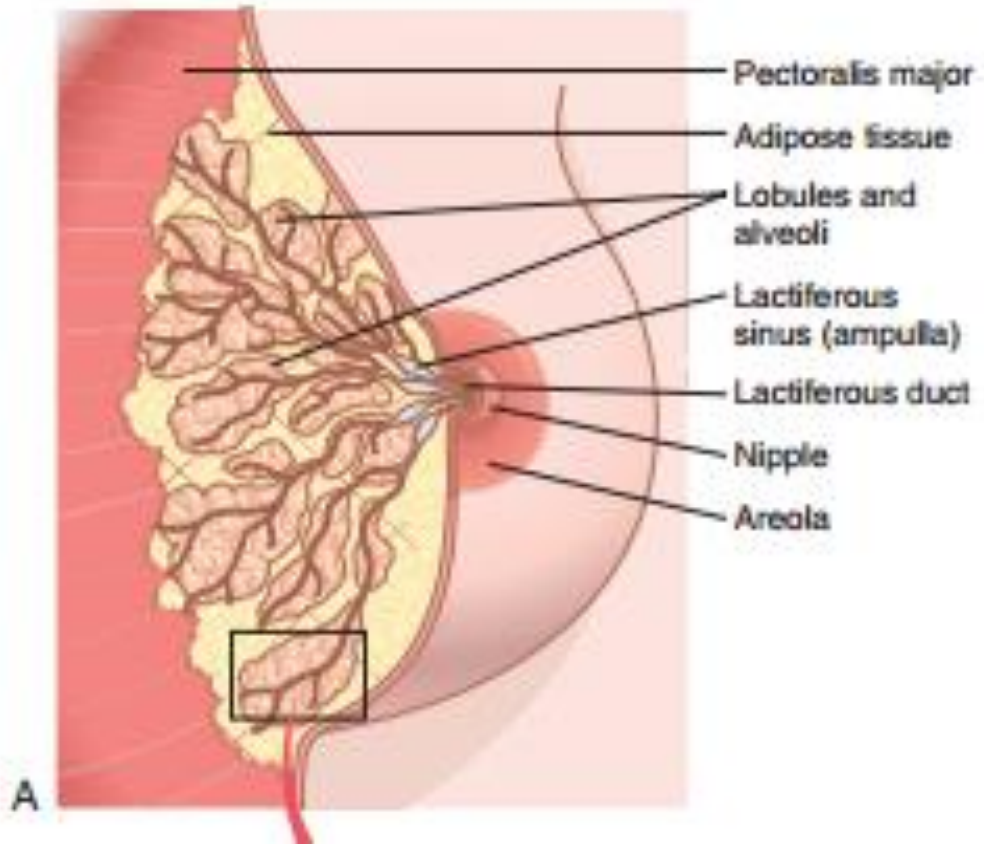
Development of the Breasts

- The breasts development begins at puberty. (estrogens)
- Estrogens stimulate growth of the breasts' mammary glands plus the deposition of fat to give the breasts mass.
- Far greater growth occurs during pregnancy, and only then does the glandular tissue become completely developed for production of milk.



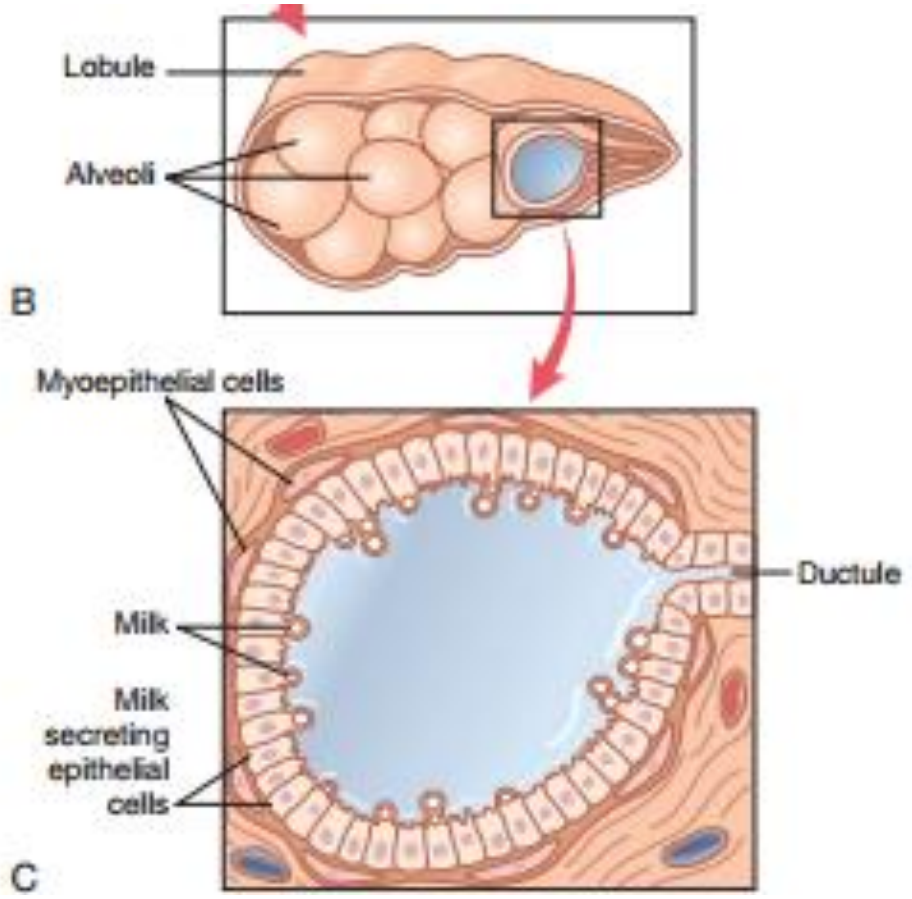
Estrogens Stimulate Growth of the Ductal System of the Breasts

- All through pregnancy, the large quantities of estrogens cause the ductal system of the breasts to grow and branch.
- The stroma of the breasts increases in quantity, and large quantities of fat are laid down in the stroma.
- Together with: growth hormone, prolactin, adrenal glucocorticoids, and insulin



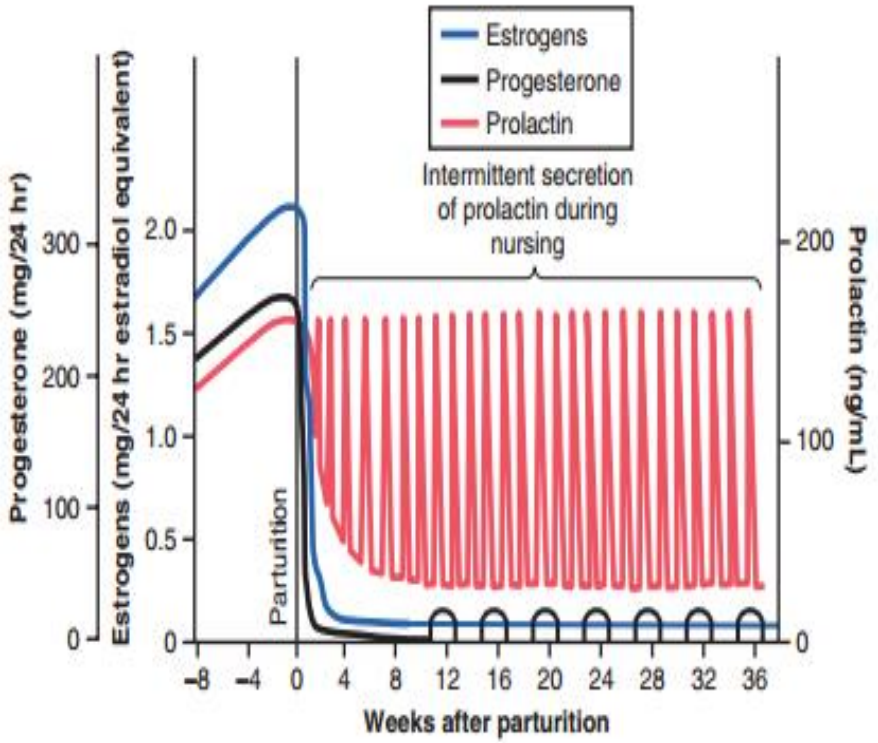
Progesterone Is Required for Full Development of the Lobule-Alveolar System

- Final development of the breasts into milk-secreting organs also requires progesterone.
- Progesterone causes additional growth of the breast lobules, with budding of alveoli and development of **secretory characteristics** in the cells of the alveoli.
- Once the ductal system has developed, progesterone—acting synergistically with estrogen, as well as with the other hormones just mentioned—causes additional growth of the breast lobules, with budding of alveoli and development of secretory characteristics in the cells of the alveoli.



PROLACTIN PROMOTES LACTATION

- Prolactin's blood concentration rises steadily from the fifth week of pregnancy-birth (10 -20X).
- Suppressive effects of estrogen and progesterone, no more than a few milliliters of fluid are secreted until after the baby is born
- Secretions around delivery→ colostrum; same concentrations of proteins and lactose as milk, but no fat.
- During the next 1 to 7 days, milk is produced instead of colostrum



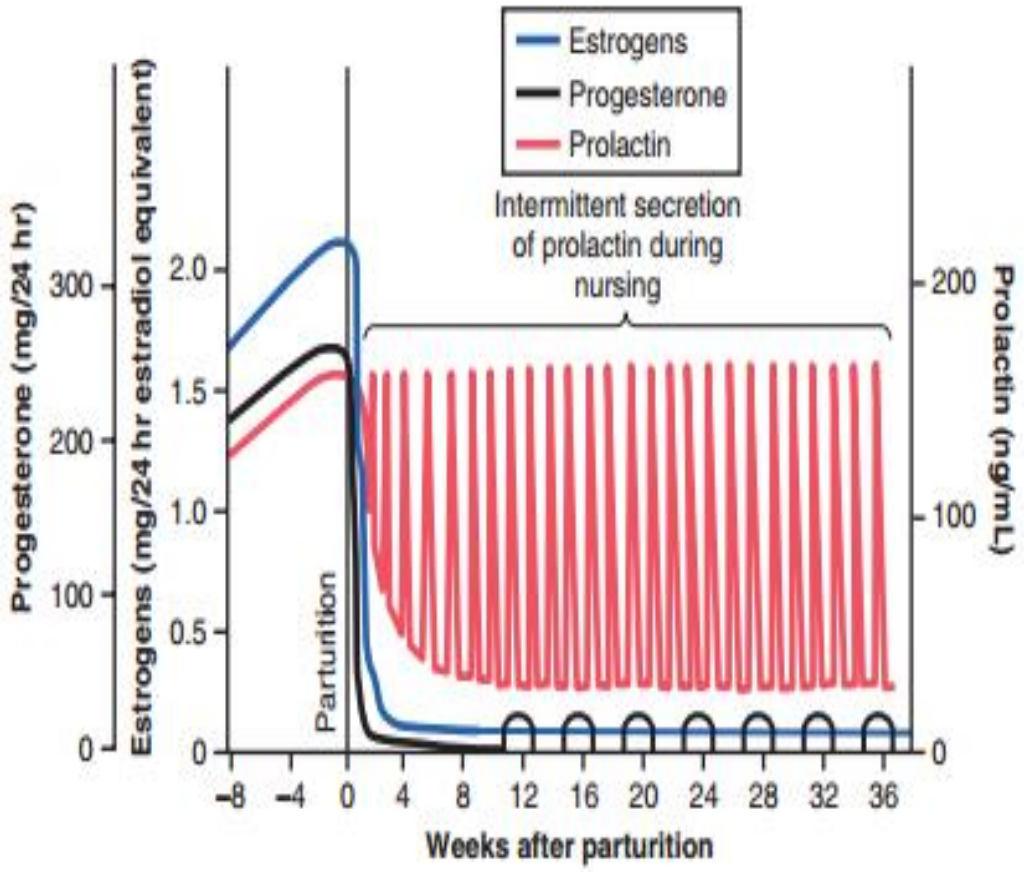
Although **estrogen and progesterone are essential for **physical development** of the breasts during pregnancy, a specific effect of both these hormones is to **inhibit the actual secretion of milk.**

**Secretions in the last few days before and the first few days after parturition is called colostrum; same concentrations of proteins and lactose as milk, but no fat , and its maximum rate 1/100 the subsequent rate of milk production.

** Requires an adequate background secretion of growth hormone, cortisol, parathyroid hormone, and insulin. (amino acids, fatty acids, glucose, and calcium)

PROLACTIN PROMOTES LACTATION

- After the birth of the baby, the basal level of prolactin secretion returns to the nonpregnant level during the next few weeks
- Nervous signals from the nipples to the hypothalamus cause a 10- to 20-fold surge in prolactin secretion that lasts~ 1 hour.
- It keeps the mammary glands secreting milk into the alveoli for the subsequent nursing periods.
- If nursing does not continue, the breasts lose their ability to produce milk within 1 week or so.

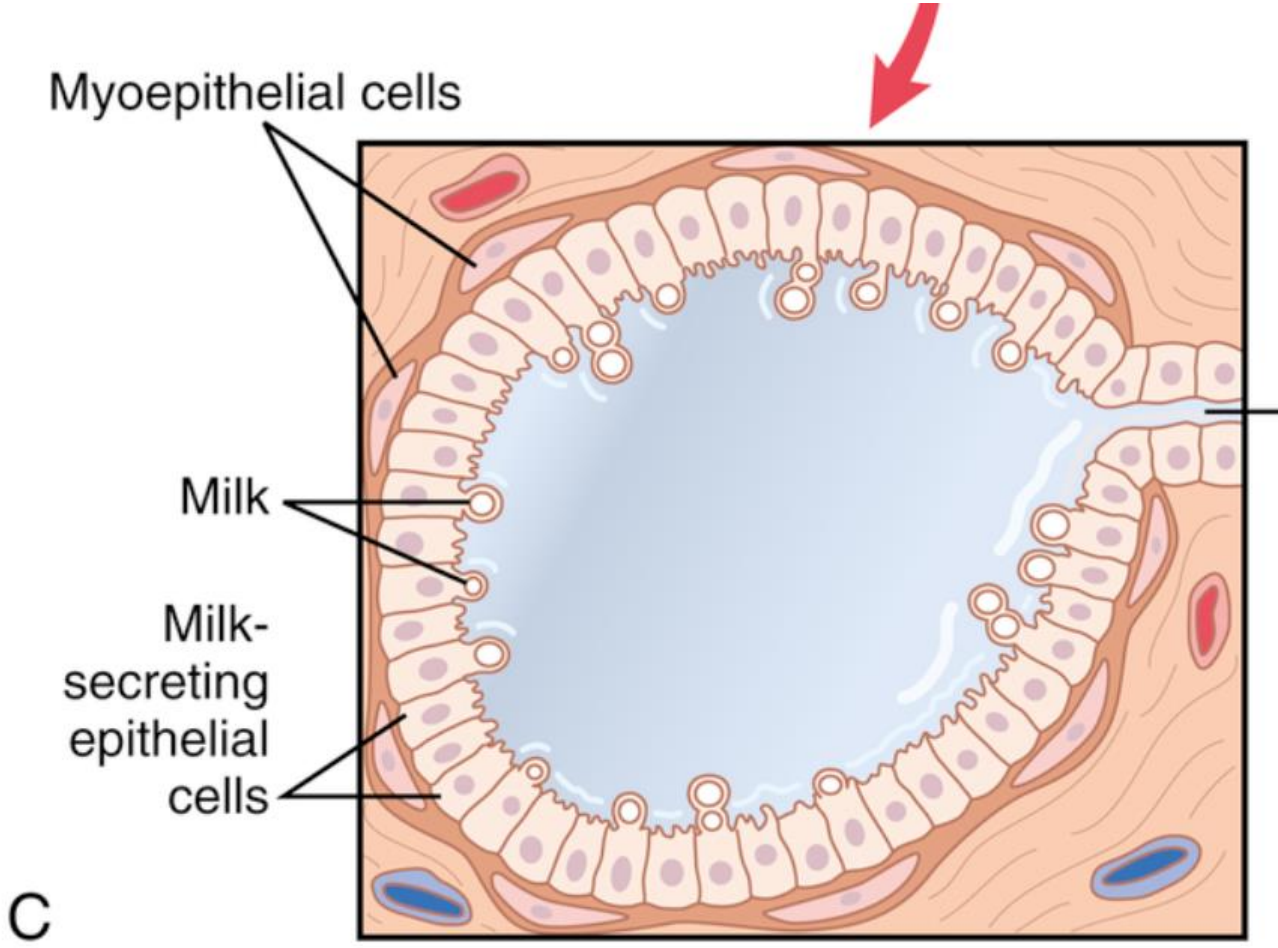


Suppression of the Female Ovarian Cycles in Nursing Mothers for Many Months After Delivery

- In most nursing mothers, the ovarian cycle (and ovulation) does not resume until a few weeks after cessation of nursing.
- Nervous signals from the breasts to the hypothalamus —either directly or through prolactin—inhibit secretion of gonadotropin-releasing hormone by the hypothalamus.
- → suppresses FSH&LH

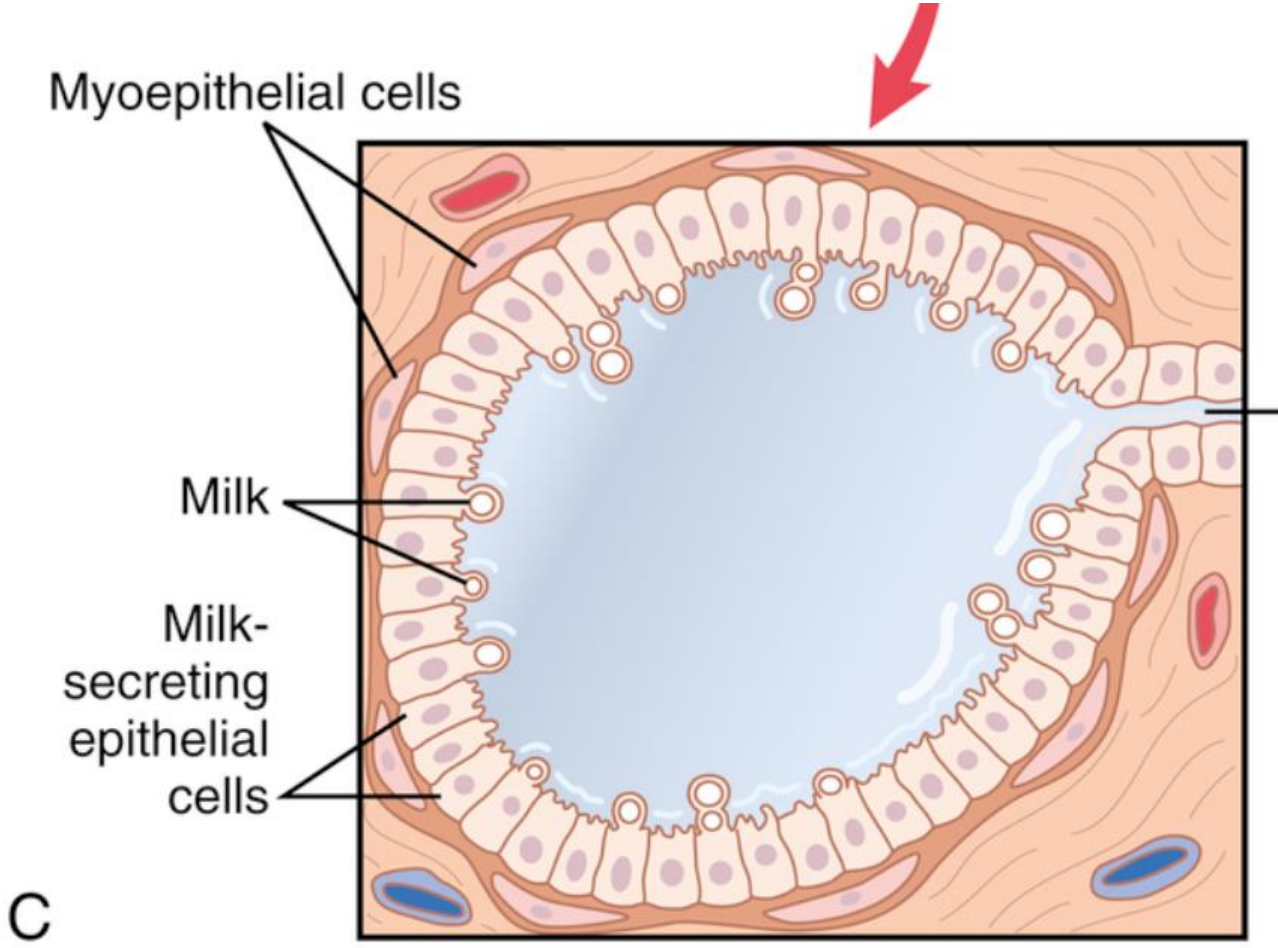
EJECTION (OR "LET-DOWN") PROCESS IN MILK SECRETION—FUNCTION OF OXYTOCIN

- Milk does not flow easily from the alveoli into the ductal system.
- When the baby suckles, it receives virtually no milk for the first half minute or so.
- Sensory impulses travels to hypothalamus to promote oxytocin secretion at the same time that they cause prolactin secretion.



EJECTION (OR "LET-DOWN") PROCESS IN MILK SECRETION—FUNCTION OF OXYTOCIN

- Oxytocin causes myoepithelial cells to contract, thereby expressing the milk from the alveoli into the ducts.
- Then the baby's suckling becomes effective in removing the milk.
- Within 30 seconds to 1 minute after a baby begins to suckle, milk begins to flow. This process is called milk ejection or milk letdown.



Thank You & Good Luck