MATERNAL PHYSIOLOGY

Ina S. Irabon, MD, FPOGS, FPSRM, FPSGE
Obstetrics and Gynecology
Reproductive Endocrinology and Infertility

To download lecture deck

Reference

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

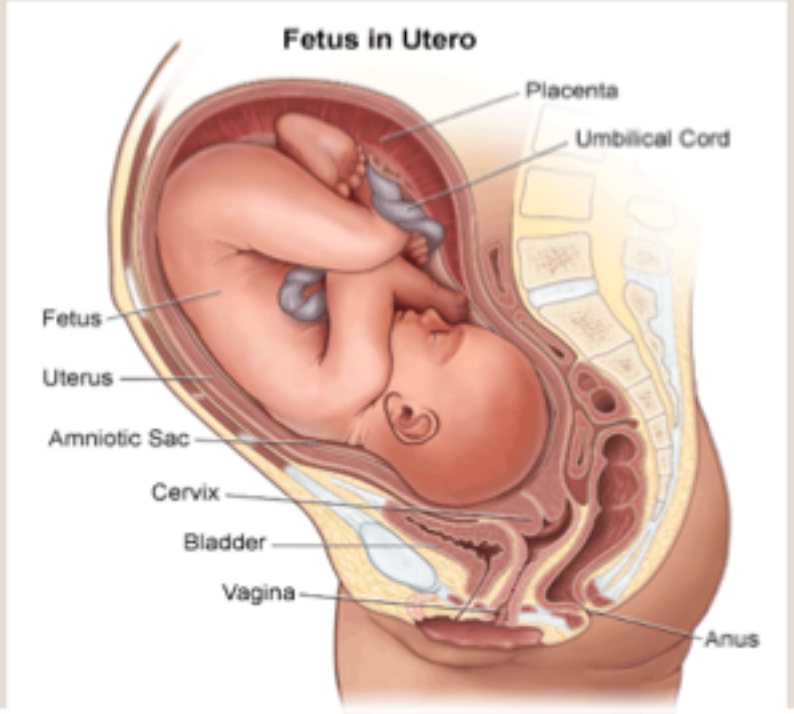
Outline

1. REPRODUCTIVE TRACT
2. BREASTS
3. SKIN
4. METABOLIC CHANGES
5. HEMATOLOGICAL CHANGES
6. CARDIOVASCULAR SYSTEM
7. RESPIRATORY TRACT
8. URINARY SYSTEM
9. GASTROINTESTINAL TRACT
10. ENDOCRINE SYSTEM

REPRODUCTIVE TRACT

Uterus

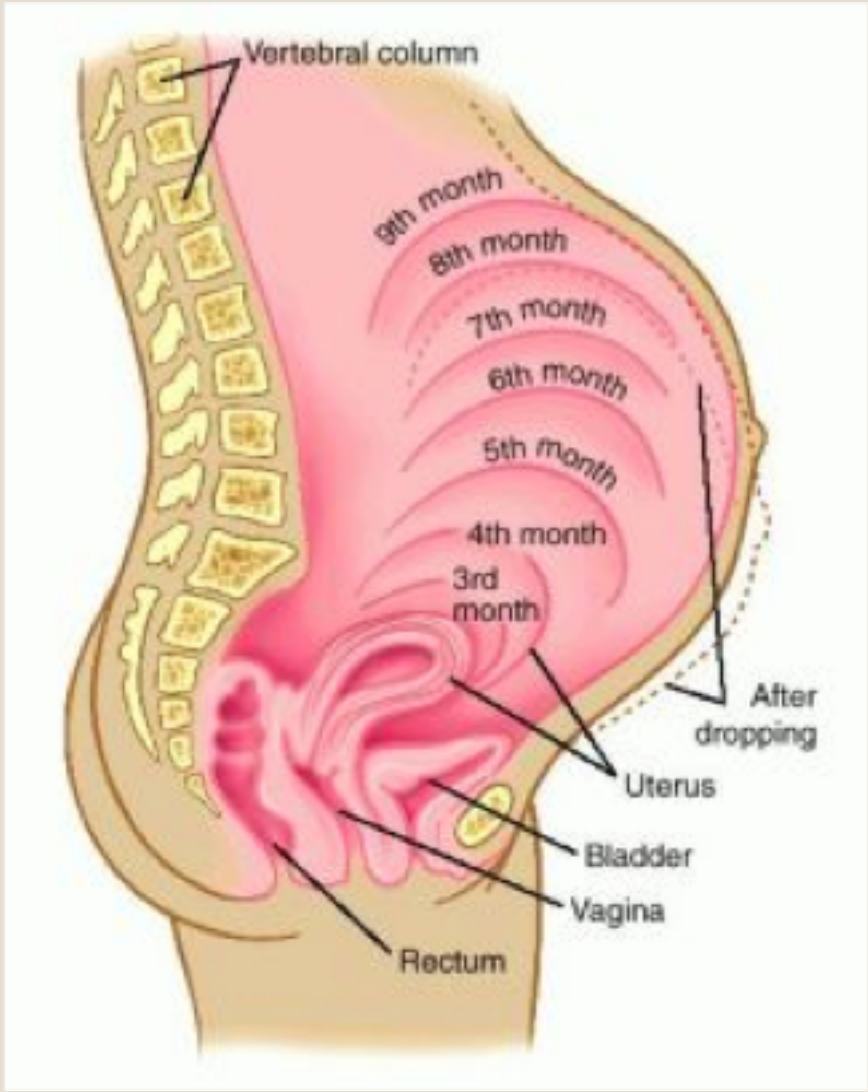
- Nonpregnant: uterus weighs approximately 70 g, mostly solid, and has a cavity of 10 mL or less.
- During pregnancy: the uterus becomes a relatively thin-walled muscular organ to accommodate the fetus, placenta, and amnionic fluid. (By the end of pregnancy, the uterus is 500-1000x greater than in the non- pregnant state)
- total volume of the contents at term: approximately 5 L (but may be 20 L or more); total weight: 1100 grams



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus

- During pregnancy, uterine enlargement involves stretching and marked hypertrophy of muscle cells, whereas the production of new myocytes is limited.
-
- Accompanying the increase in myocyte size is an accumulation of fibrous tissue, particularly in the external muscle layer, together with a considerable increase in elastic tissue content → this network adds strength to the uterine wall.

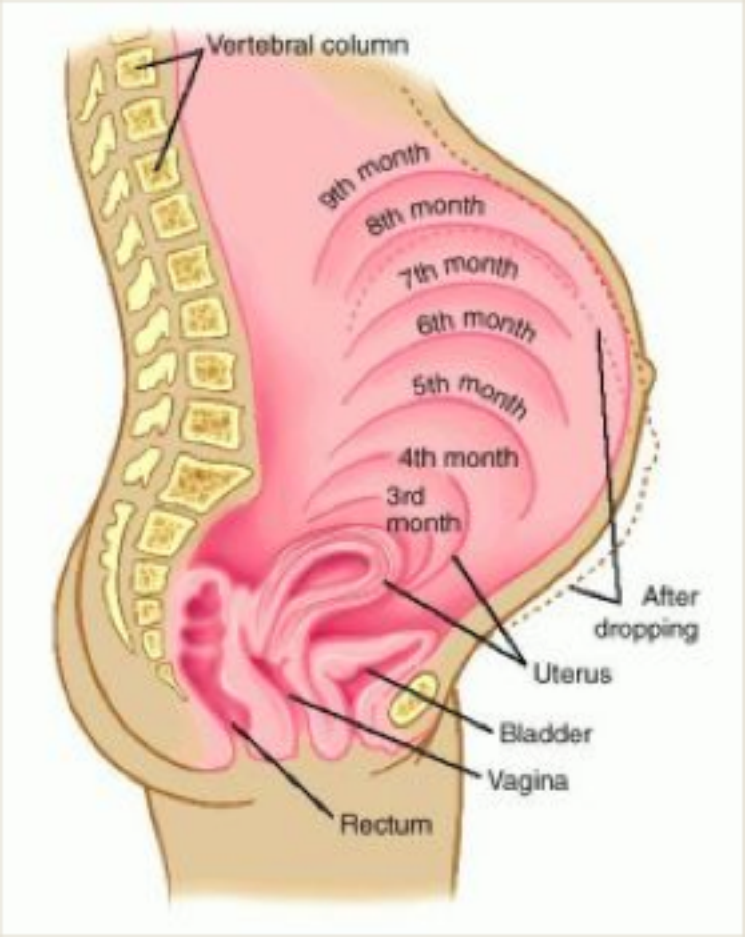


- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus

- The hypertrophy of early pregnancy does not occur entirely in response to mechanical distention by the products of conception, because similar uterine changes are observed with ectopic pregnancy

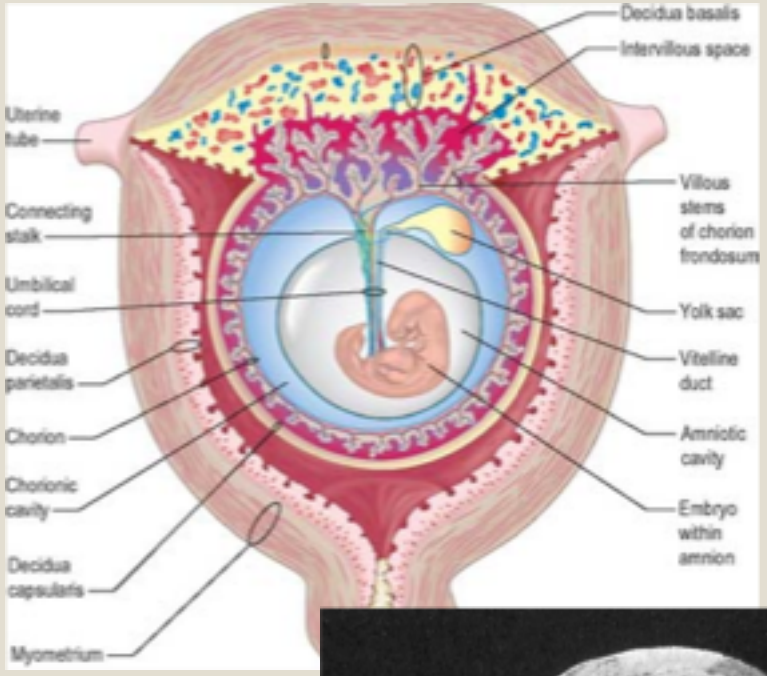
- Uterine hypertrophy early in pregnancy is stimulated by estrogen and progesterone.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus

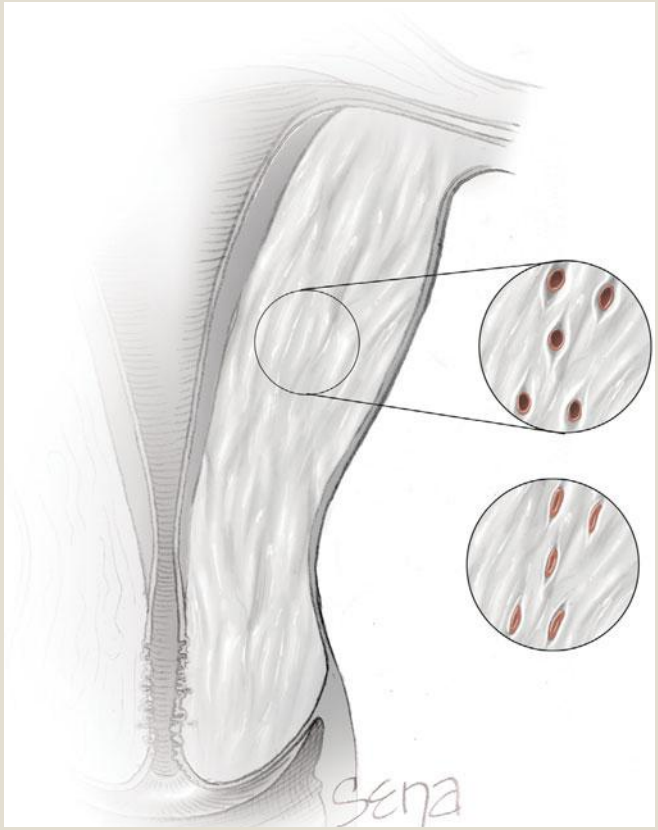
- after approximately 12 weeks, the uterine size increase is due to pressure exerted by the expanding products of conception.
- In early pregnancy, the fallopian tubes and the ovarian and round ligaments attach only slightly below the apex of the fundus.
- In later months, they are located slightly above the middle of the uterus.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus: Myocyte Arrangement

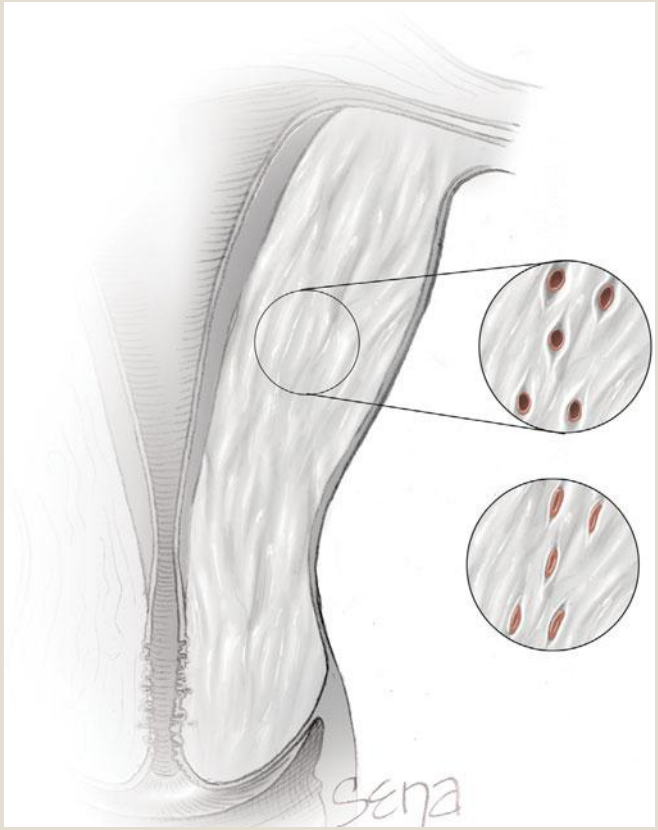
- Uterine musculature during pregnancy is arranged in 3 strata:
  - outer hoodlike layer: arches over the fundus and extends into the various ligaments.
  - middle layer: dense network of muscle fibers perforated in all directions by blood vessels.
  - internal layer: sphincter-like fibers around the fallopian tube orifices and internal cervical os.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus

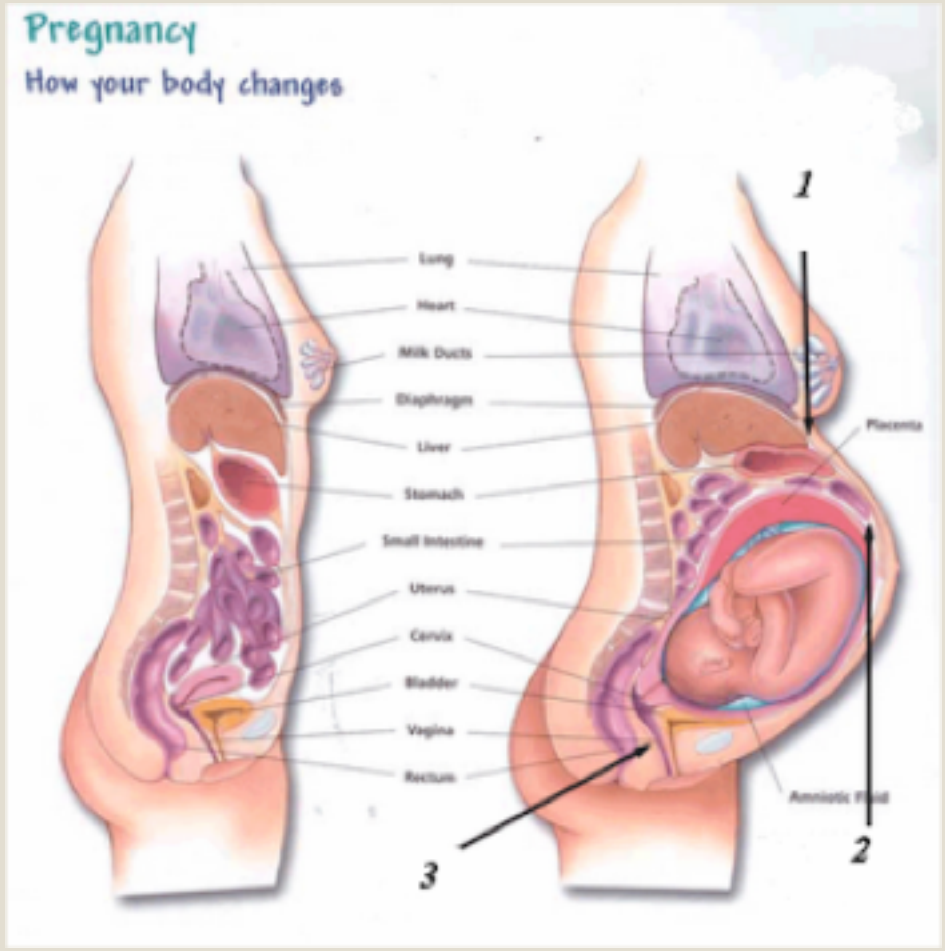
- Most of the uterine wall is formed by the middle layer.
- Each cell in this layer has a double curve so that the interlacing of any two gives approximately the form of a figure eight.
- This arrangement is crucial because when the cells contract after delivery, they constrict penetrating blood vessels and thus act as ligature.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uterus: Size, Shape, and Position

- < 12 wks AOG: the uterus is piriform or pear shape.
- ≥12 wks AOG: the corpus and fundus become globular and almost spherical
- As the uterus enlarges, it contacts the anterior abdominal wall, displaces the intestines laterally and superiorly, and ultimately reaches almost to the liver.
- It usually rotates to the right (dextrorotation) -→ caused by the rectosigmoid on the left side of the pelvis.
- As the uterus rises, tension is exerted on the broad and round ligaments.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

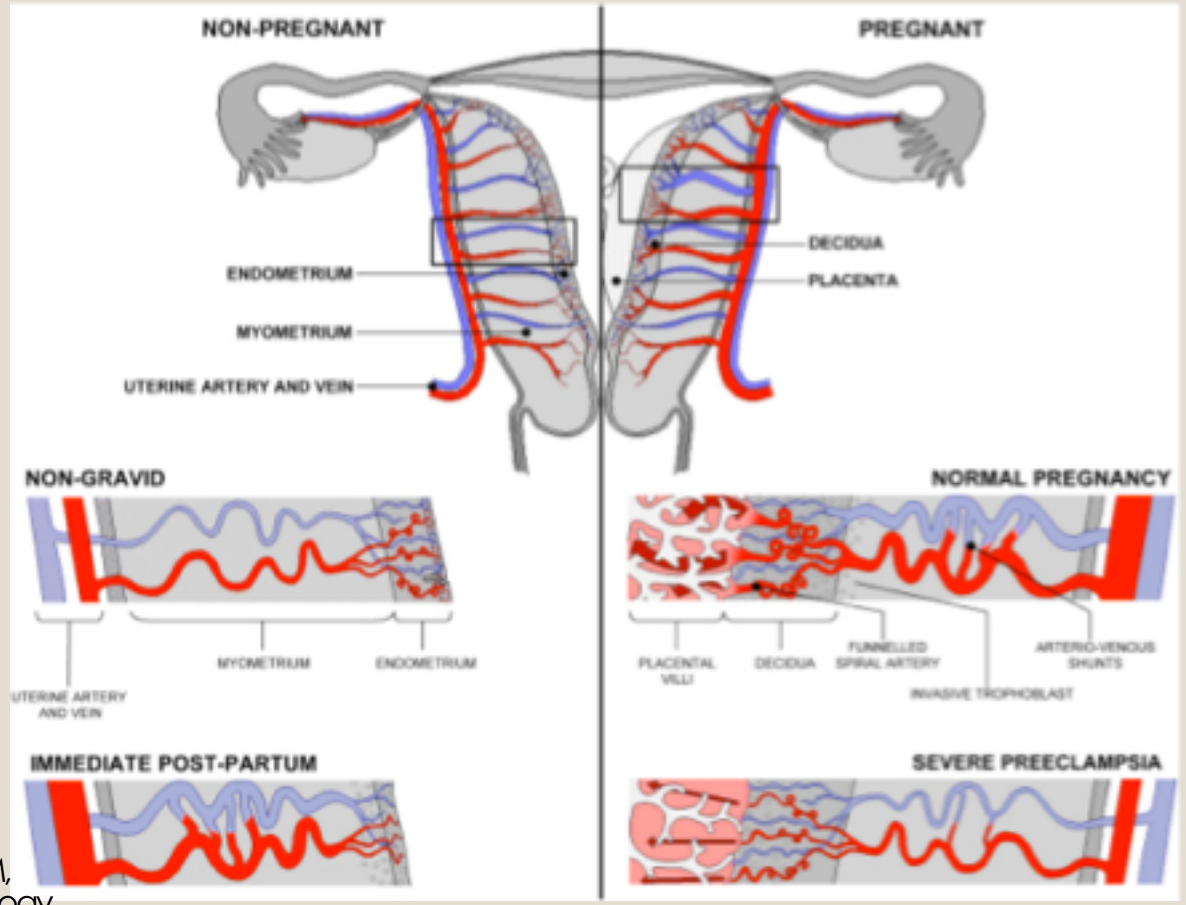
Uterine Contractility

- Beginning in early pregnancy, the uterus undergoes irregular contractions that are normally painless.
- During the second trimester, these contractions may be detected by bimanual examination (Braxton Hicks contractions)
- These contractions are unpredictable, infrequent, sporadic and nonrhythmic.
- their number increases during the last two weeks of pregnancy → account for so-called "false labor"

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uteroplacental Blood Flow

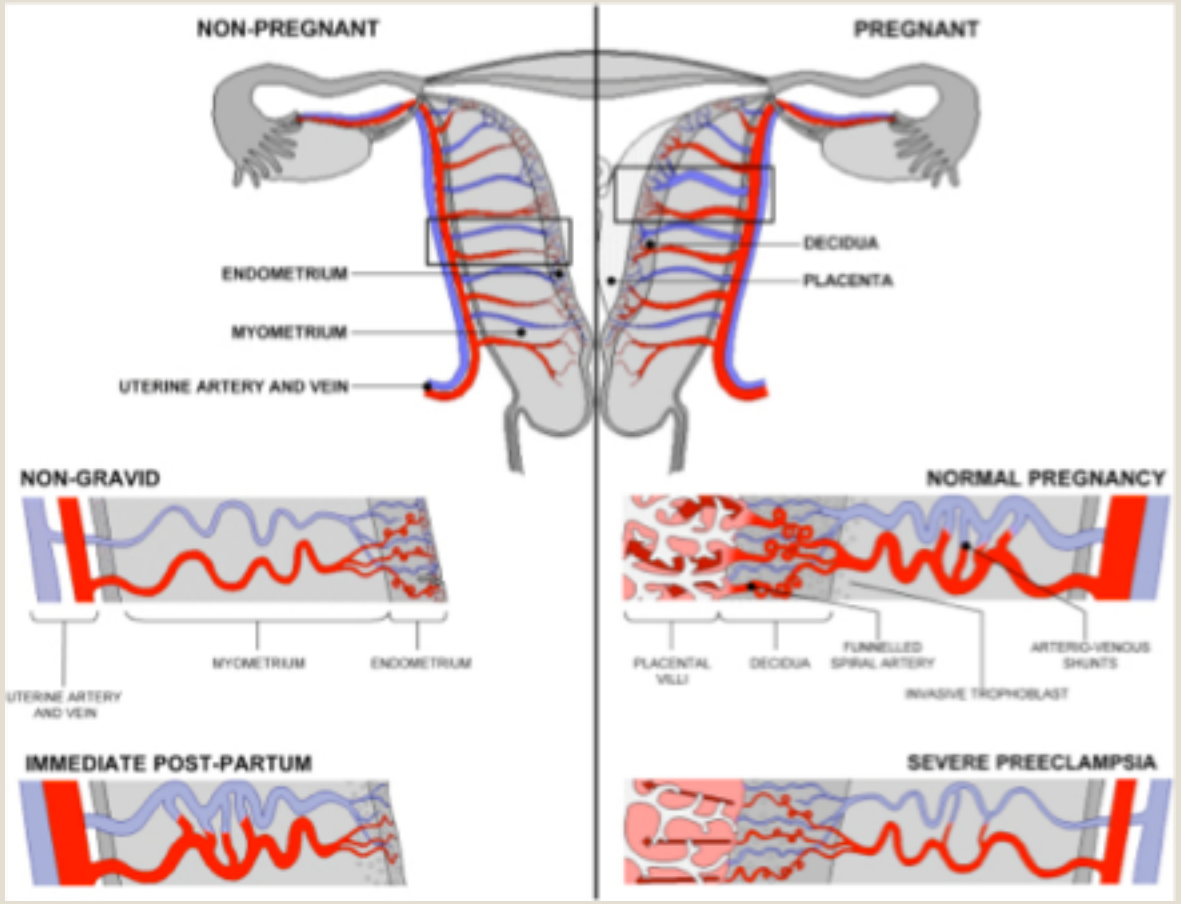
- Uteroplacental blood flow was found to increase progressively during pregnancy. Estimates range from 450 to 650 mL/min near term
- Uterine veins increase caliber and distensibility to accommodate the massively increased uteroplacental blood flow.
- Uterine contractions cause a decrease in uterine blood flow approximately proportional to the contraction intensity.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Uteroplacental Blood Flow

- Maternal-placental blood flow progressively increases during gestation principally by means of vasodilation (secondary to estrogen, progesterone and relaxin)
- Normal pregnancy is also characterized by vascular refractoriness to the pressor effects of infused angiotensin II and nor-epinephrine → this insensitivity also serves to increase uteroplacental blood flow



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Cervix

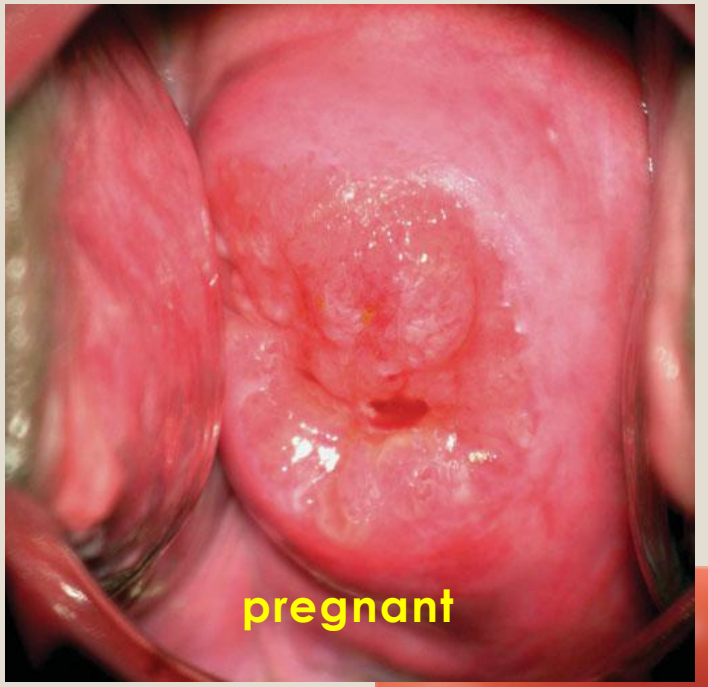
- As early as 1 month after conception, the cervix begins to undergo pronounced softening and cyanosis (bluish discoloration) (Chadwick sign)

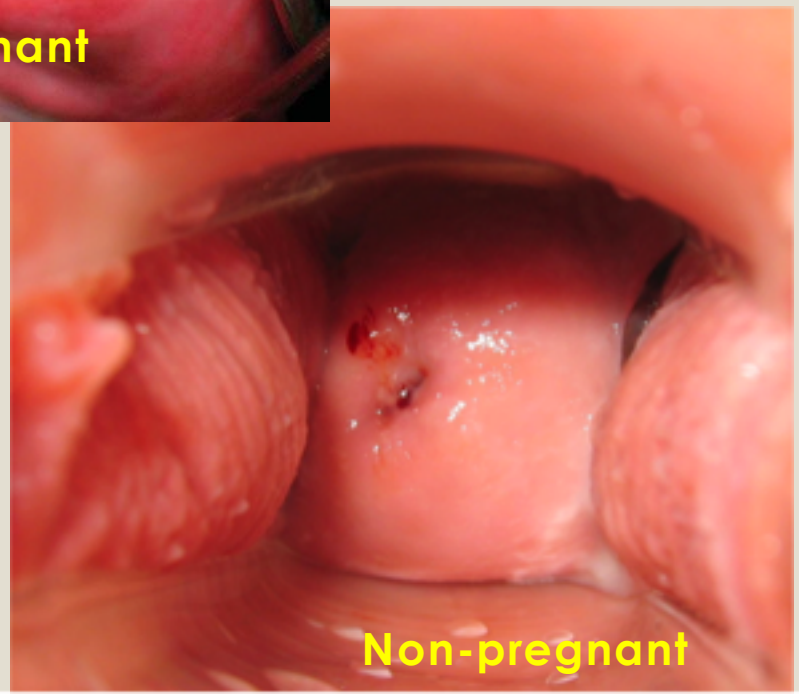
- increased vascularity and edema of the entire cervix, together with hypertrophy and hyperplasia of the cervical glands

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Cervix

- **Cervical eversion of pregnancy**
- →extension, or eversion, of the proliferating columnar endocervical glands.
- → tends to be red and velvety and bleeds even with minor trauma, such as with Pap smear sampling.

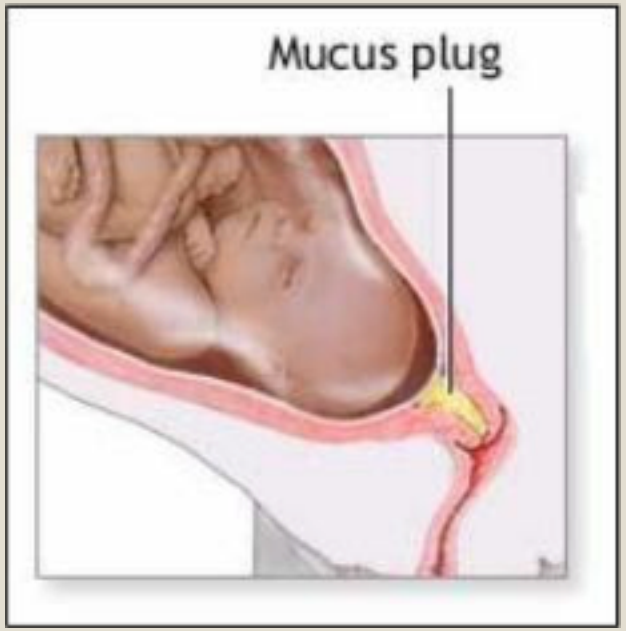


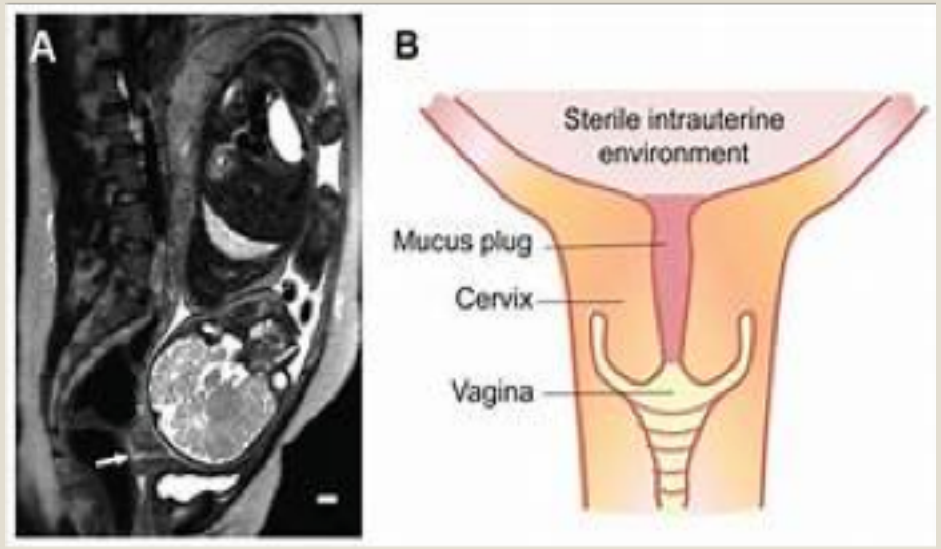


- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Cervix

- "**Mucus plug**" →copious tenacious mucus that obstruct the cervical canal soon after conception.
- → rich in immunoglobulins and cytokines and may act as an immunological barrier to protect the uterine contents against infection
- At the onset of labor, if not before, this mucus plug is expelled, resulting in a "**bloody show**".

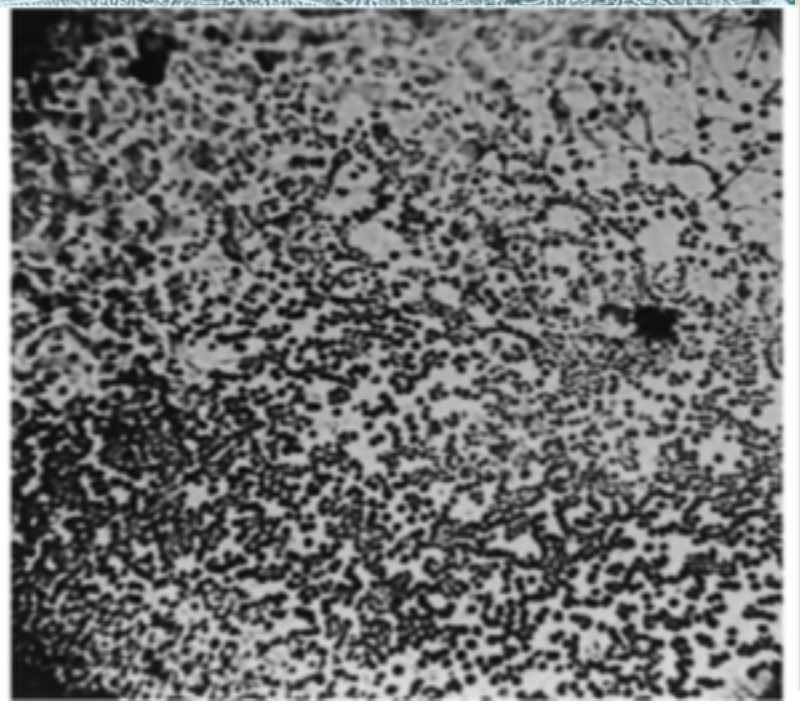




- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Cervix

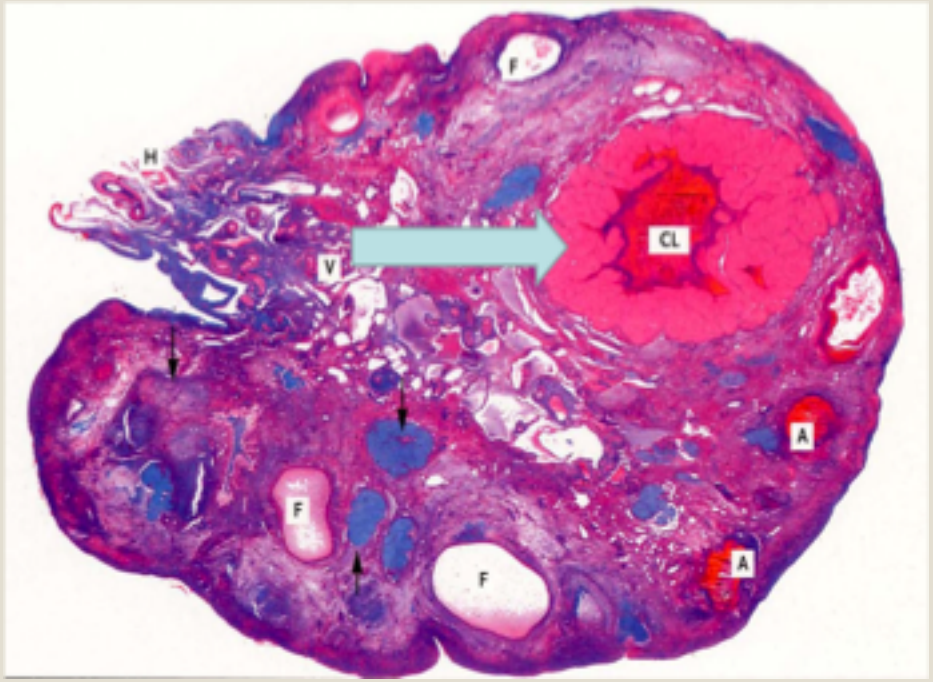
- poor crystallization, or beading of cervical mucus when it is spread and dried on a glass slide (progesterone effect)
- In some women, an arborization of crystals, or ferning, is observed as a result of amnionic fluid leakage
- During pregnancy, basal cells near the squamocolumnar junction are likely to be prominent in size, shape, and staining qualities (estrogen induced)
- *Arias-Stella reaction* →endocervical gland hyperplasia and hypersecretory appearance during pregnancy



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Ovaries

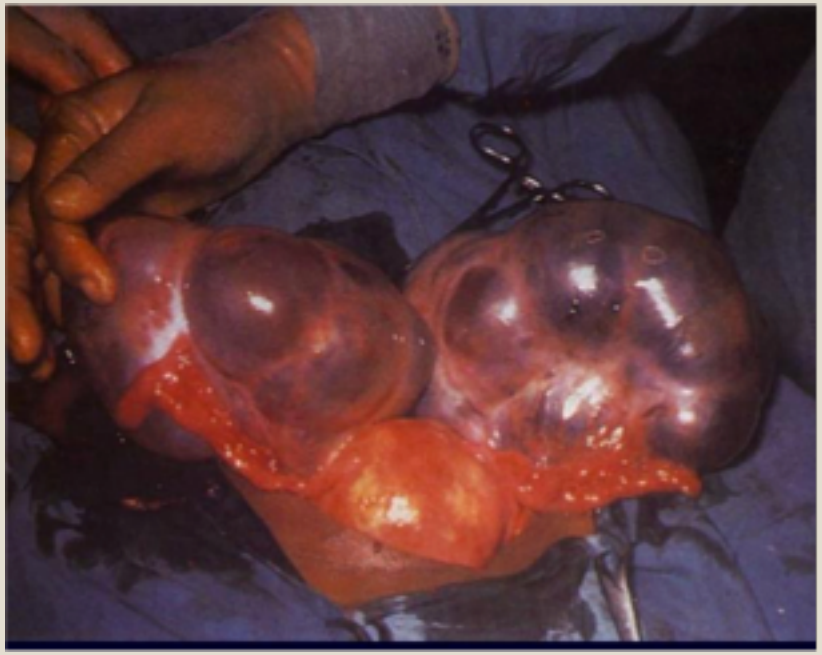
- Ovulation ceases during pregnancy, and maturation of new follicles is suspended.
- the single corpus luteum found in pregnant women functions maximally during the first 6 to 7 weeks of pregnancy
- surgical removal of the corpus luteum before 7 weeks AOG → rapid fall in maternal serum progesterone levels and spontaneous abortion
  - (After this time, however, corpus luteum excision ordinarily does not cause abortion, and even bilateral oophorectomy at 16 weeks does not cause pregnancy loss)



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Theca-Lutein Cysts

- benign ovarian lesions resulting from exaggerated physiological follicle stimulation—termed hyperreactio luteinalis
- associated with markedly elevated serum levels of hCG.
- found frequently with gestational trophoblastic disease, large placenta such as with diabetes, anti-D alloimmunization, and multifetal gestations
- reported in chronic renal failure as a result of reduced hCG clearance and in hyperthyroidism as a result of the structural homology between hCG and thyroid-stimulating hormone (TSH)



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Theca-Lutein Cysts

- usually asymptomatic
- hemorrhage into the cysts may cause abdominal pain
- Maternal virilization may be seen in up to 30% of women → temporal balding, hirsutism, and clitoromegaly are associated with massively elevated levels of androstenedione and testosterone.
- This condition is self-limited, and resolution follows delivery.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Vagina and Perineum

- Chadwick sign –violaceous/purplish color of vaginal walls due to increased vascularity
- increased volume of cervical secretions within the vagina during pregnancy consists of a somewhat thick, white discharge.
- pH is acidic, varying from 3.5 to 6. is results from increased production of lactic acid from glycogen in the vaginal epithelium by the action of *Lactobacillus acidophilus*.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

BREASTS

Breasts

- In the early weeks of pregnancy, women often experience breast tenderness and paresthesias.
- After the second month, the breasts increase in size, and delicate veins become visible just beneath the skin.
- the nipples become considerably larger, more deeply pigmented, and more erectile.
- After the first few months, a thick, yellowish fluid—colostrum—can often be expressed from the nipples by gentle massage.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

SKIN

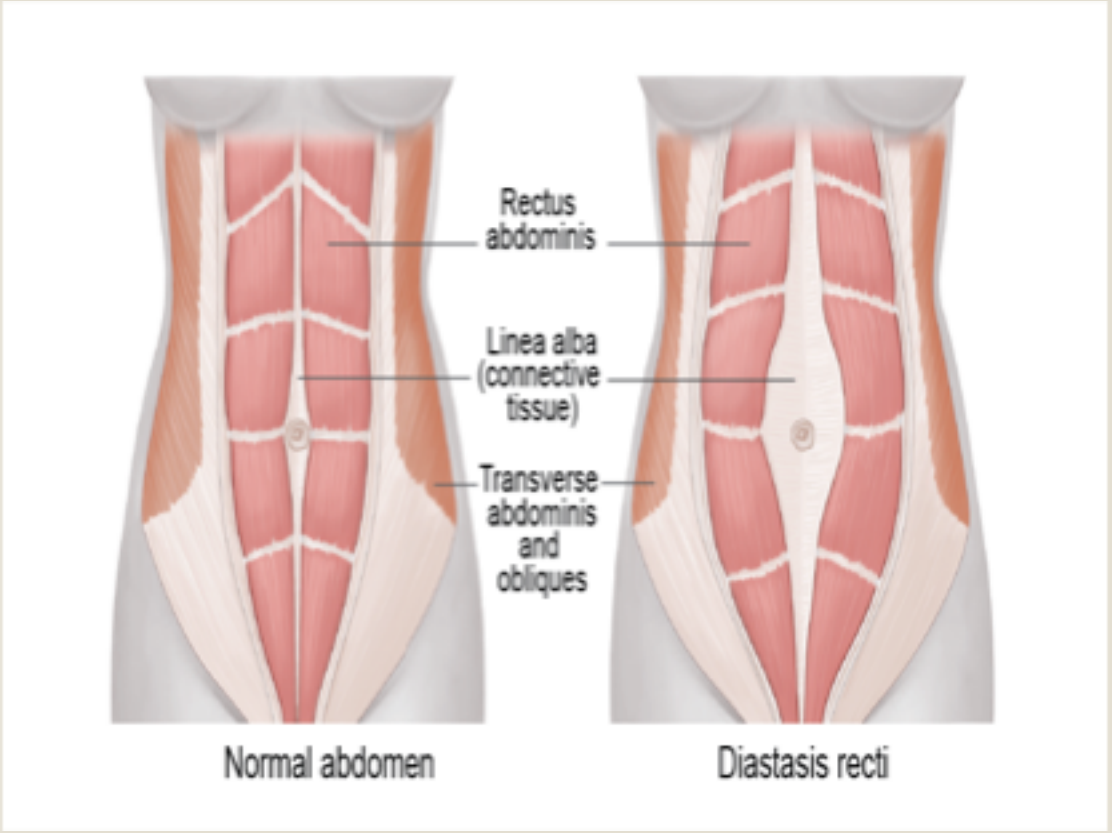
Abdominal Wall

- **striae gravidarum or stretch marks** - reddish, slightly depressed streaks commonly develop in the abdominal skin and sometimes in the skin over the breasts and thighs.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Abdominal wall

- **Diastasis recti** → rectus muscles separate in the midline when the muscles of the abdominal walls do not withstand the tension to which they are subjected.
- If severe, a considerable portion of the anterior uterine wall is covered by only a layer of skin, attenuated fascia, and peritoneum to form a ventral hernia



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Hyperpigmentation

- **linea nigra** → linea alba takes on dark brown-black pigmentation
- **chloasma or melasma gravidarum** → "mask of pregnancy"; irregular brownish patches of varying size appear on the face and neck
- these pigmentary changes usually disappear, or at least regress considerably, after delivery. (Oral contraceptives may cause similar pigmentation)
- Pigmentary changes due to markedly increased levels of melanocyte-stimulating hormone. Estrogen and progesterone also are reported to have melanocyte-stimulating effects.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Vascular changes

- **Angiomas/ "vascular spiders"** → minute, red skin elevations, with radicles branching out from a central lesion
- common on the face, neck, upper chest, and arms
- **Palmar erythema** is encountered during pregnancy in approximately two thirds of white women and one third of black women.
- **these two conditions are most likely due to hyperestrogenemia.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

METABOLIC CHANGES

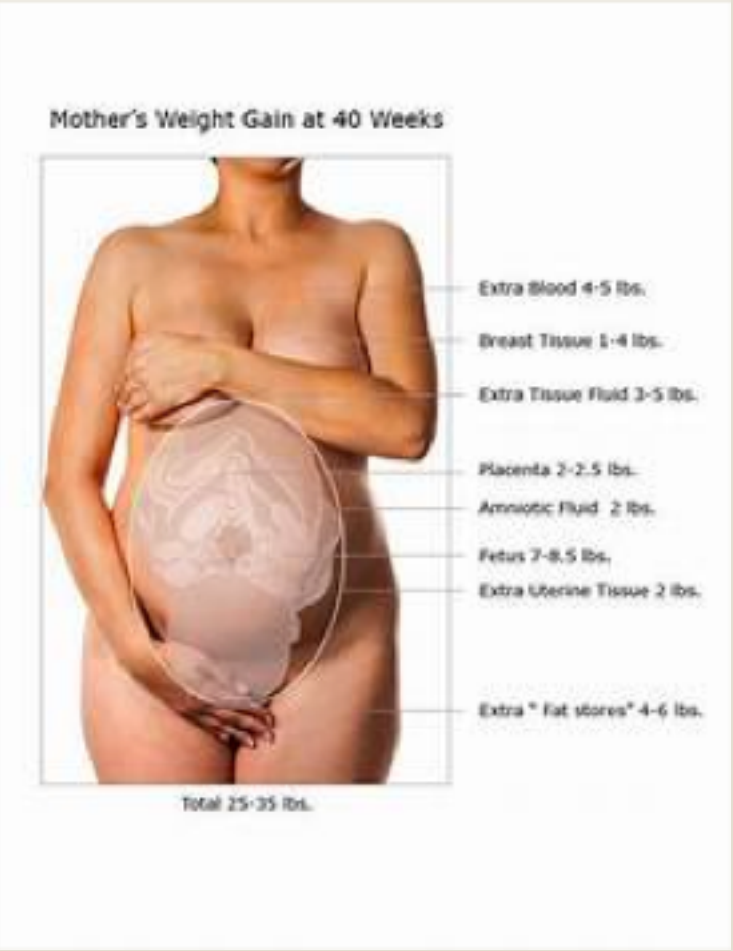
- By the third trimester, maternal basal metabolic rate is increased by 10 to 20 percent compared with that of the non- pregnant state.

- World Health Organization (2004): additional total pregnancy energy demands associated with normal pregnancy are approximately:
  - First trimester: 85 kcal/day
  - Second trimester: 285 kcal/day
  - Third trimester: 475 kcal/day

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Weight Gain

- Most of the normal increase in weight during pregnancy is attributable to the uterus and its contents, the breasts, and increases in blood volume and extravascular extracellular fluid.
- A smaller fraction results from metabolic alterations that increase accumulation of cellular water, fat, and protein—so- called maternal reserves.
- average weight gain during pregnancy is approximately **12.5 kg or 27.5 lb**



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Water Metabolism

- Increased water retention is a normal physiological alteration of pregnancy.
- minimum amount of extra water that the average woman gains during normal pregnancy is approximately 6.5 L.
  - water content of the fetus, placenta, and amnionic fluid =3.5 L.
  - increases in maternal blood volume and in the size of the uterus and breasts = 3L

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Water Metabolism

- pitting edema of the ankles and legs → (may amount to a liter or so)
- → caused by increased venous pressure below the level of the uterus as a consequence of partial vena cava occlusion.
  - → A decrease in interstitial colloid osmotic pressure induced by normal pregnancy also favors edema late in pregnancy

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Carbohydrate Metabolism

- Normal pregnancy is characterized by mild fasting hypoglycemia, postprandial hyperglycemia, and hyperinsulinemia
- **pregnancy-induced state of peripheral insulin resistance** → to ensure a sustained postprandial supply of glucose to the fetus.
- Progesterone and estrogen may act, directly or indirectly, to mediate this insulin insensitivity
- "**Accelerated starvation**" → pregnancy-induced switch in fuels from glucose to lipids
  - *pregnant woman changes rapidly from a postprandial state characterized by elevated and sustained glucose levels to a fasting state characterized by decreased plasma glucose and high plasma concentrations of free fatty acids, triglycerides, and cholesterol*

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Fat Metabolism

- Increased insulin resistance and estrogen stimulation during pregnancy are responsible for the maternal hyperlipidemia.
- increased lipid synthesis and food intake contribute to maternal fat accumulation during the first two trimesters.
- in the third trimester, however, fat storage declines or ceases due to enhanced lipolytic activity → favors maternal use of lipids as an energy source and spares glucose and amino acids for the fetus.
- After delivery, the concentrations of these lipids, as well as lipoproteins and apolipoproteins decrease

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Mineral metabolism

- Iodine requirements increase during normal pregnancy for several reasons:
  - 1) maternal thyroxine (T4) production increases to maintain maternal euthyroidism and to transfer thyroid hormone to the fetus early in gestation before the fetal thyroid is functioning
  - 2) fetal thyroid hormone production increases during the second half of pregnancy →contributes to increased maternal iodine requirements because iodide readily crosses the placenta.
  - 3)Beginning in early pregnancy, the iodide GFR increases by 30 to 50%

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

HEMATOLOGIC CHANGES

Blood Volume

- **Pregnancy-induced hypervolemia** has several important functions:
  - 1) To meet the metabolic demands of the enlarged uterus and its greatly hypertrophied vascular system.
  - 2) it provides abundant nutrients and elements to support the rapidly growing placenta and fetus.
  - 3) protects the mother and the fetus against the deleterious effects of impaired venous return in the supine and erect positions.
  - 3) it safeguards the mother against the adverse effects of parturition-associated blood loss.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

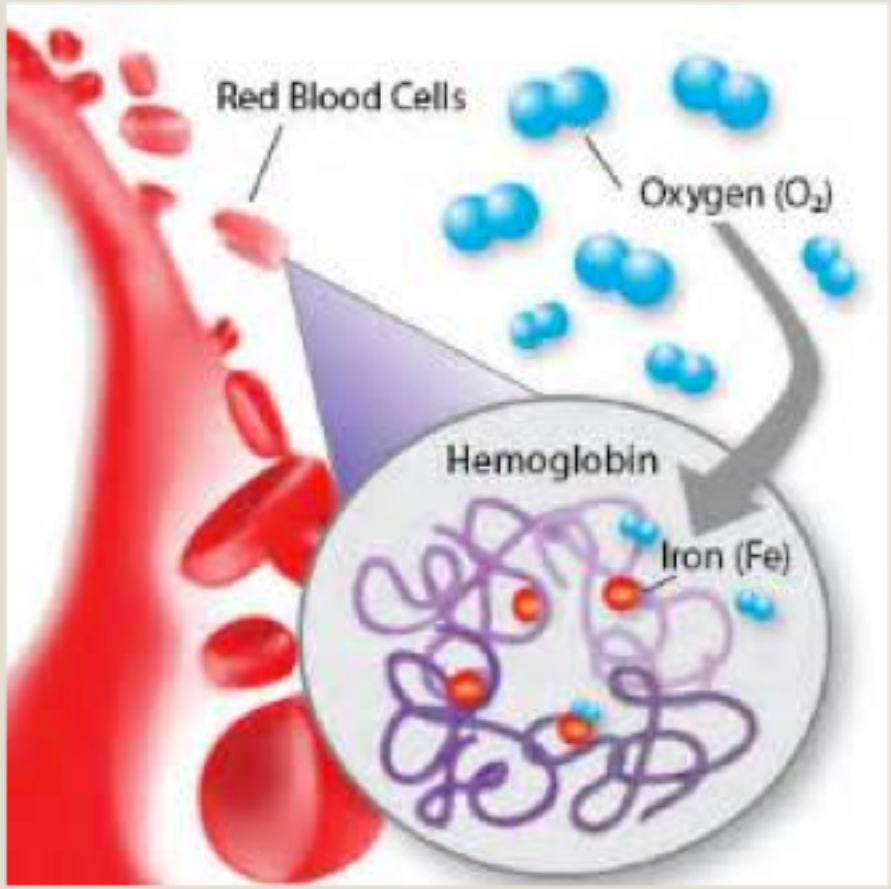
Hemoglobin Concentration and Hematocrit

- Because of great plasma augmentation, hemoglobin concentration and hematocrit decrease slightly during pregnancy (dilutional anemia)
-
- Hemoglobin concentration at term averages 12.5 g/dL, and in approximately 5 percent of women, it is below 11.0 g/dL
- thus, a hemoglobin concentration below 11.0 g/dL, especially late in pregnancy, should be considered abnormal and usually due to iron deficiency rather than pregnancy hypervolemia.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Iron requirements

- Normal pregnancy total iron requirement: 1000 mg
  - about 300 mg are actively transferred to the fetus and placenta,
  - 200 mg are lost through various normal excretion routes, primarily the gastrointestinal tract.
  - increase in the total circulating erythrocyte volume (=450 mL) → requires another 500 mg.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Iron requirements

- most iron is used during the latter half of pregnancy →averages 6 to 7 mg/day
- without supplemental iron, the optimal increase in maternal erythrocyte volume will not develop, and the hemoglobin concentration and hematocrit will decrease as plasma volume increases
- however, fetal red cell production is not impaired because the placenta transfers iron even if the mother has severe iron deficiency anemia

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Immunological Functions

- pregnancy can be divided into three distinct immunological phases:
  - **1)early pregnancy is pro-inflammatory**. During implantation and placentation, the blastocyst invades endometrial tissue, and trophoblasts replace the endothelium and vascular smooth muscle of the maternal blood vessels → create a veritable "battleground" of invading cells, dying cells, and repairing cells.
  - 2) **midpregnancy is anti-inflammatory**. During this period of rapid fetal growth and development, the predominant immunological feature is induction of an anti-inflammatory state.
  - 3) parturition is characterized by an influx of immune cells into the myometrium to promote recrudescence of an inflammatory process.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Immunological Functions

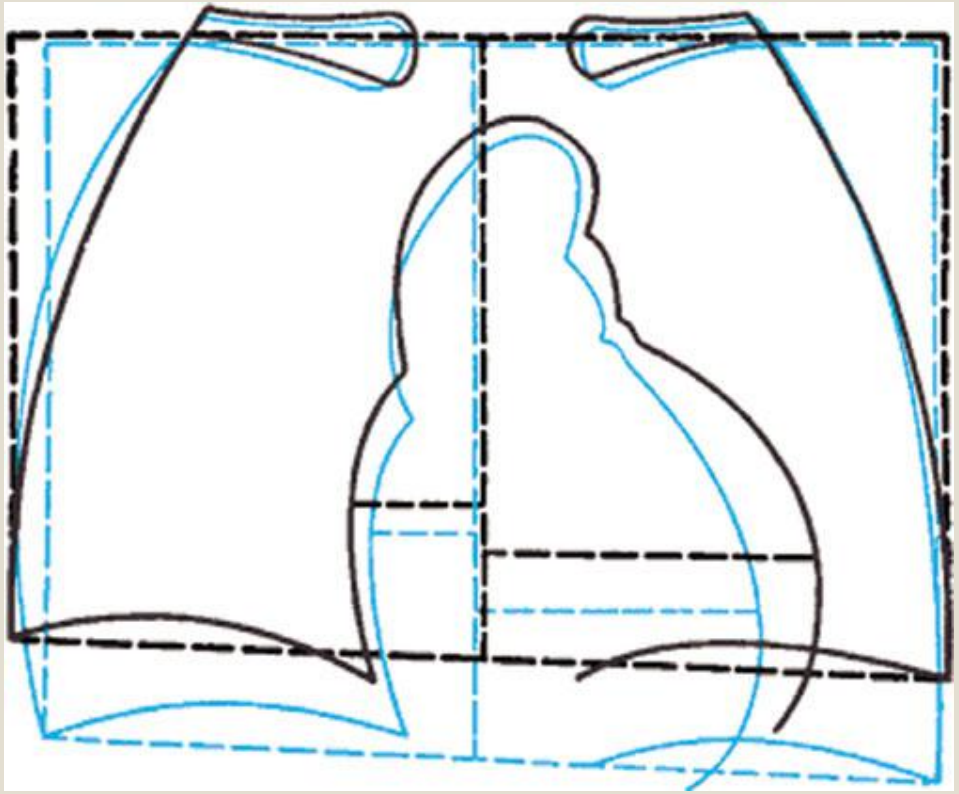
- suppression of T-helper (Th) 1 and T-cytotoxic (Tc) 1 cells, which decreases secretion of interleukin-2 (IL- 2), interferon-γ, and tumor necrosis factor-β (TNF-β).
  - → explains **pregnancy-related remission of some autoimmune disorders** such as rheumatoid arthritis, multiple sclerosis, and Hashimoto thyroiditis—which are Th1-mediated diseases
- upregulation of 2 cells to increase secretion of IL-4, IL-6, and IL-13

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

CARDIOVASCULAR SYSTEM

Heart

- heart is displaced to the left and upward and is rotated on its long axis.
- the apex is moved somewhat laterally from its usual position and produces a larger cardiac silhouette in chest radiographs



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Heart

- Many of the normal cardiac sounds are modified during pregnancy:
  1. an exaggerated splitting of the first heart sound and increased loudness of both components
  2. a loud, easily heard third sound
  3. systolic murmur intensified during inspiration in some or expiration in others and that disappeared shortly after delivery.
  4. A soft diastolic murmur may also be noted transiently
  5. continuous murmurs arising from the breast vasculature in 10 percent.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Cardiac output

- mean arterial pressure and vascular resistance decrease (beginning midpregnancy)
- blood volume and basal metabolic rate increase.
- As a result, cardiac output at rest, when measured in the lateral recumbent position, increases significantly beginning in early pregnancy
- During late pregnancy in a supine woman, the large uterus compresses venous return from the lower body and may also compress the aorta → cardiac filling may be reduced and cardiac output diminished.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

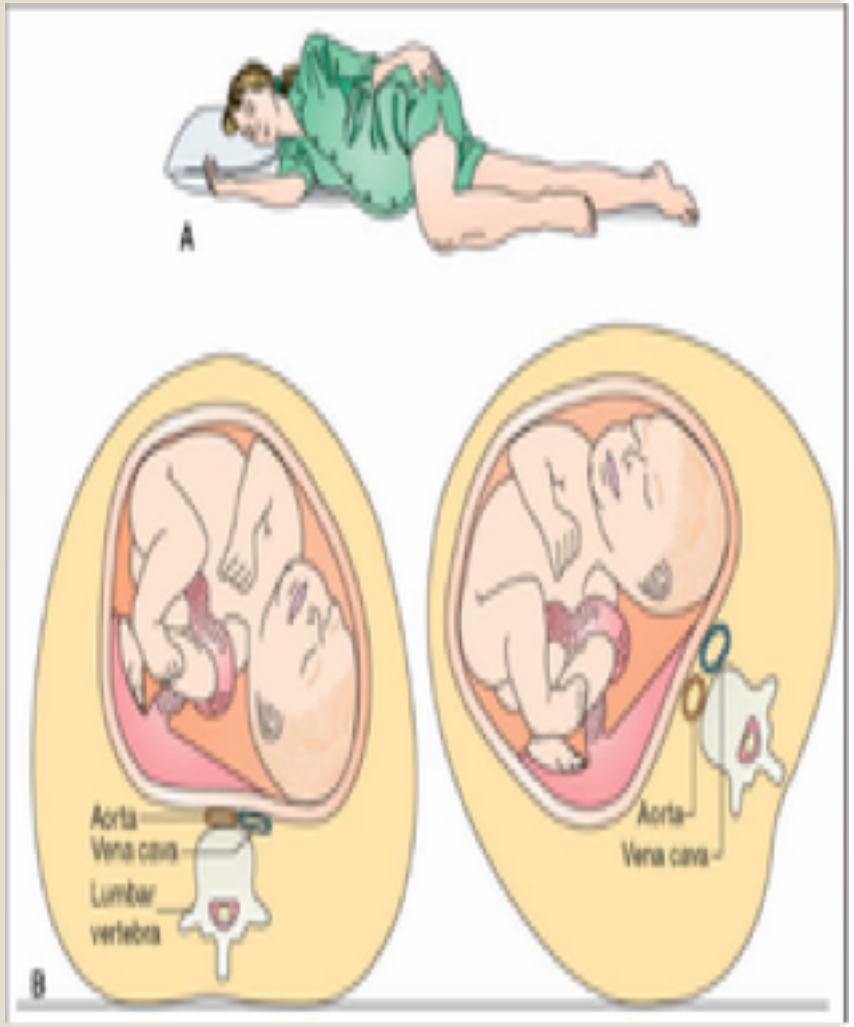
Circulation and blood pressure

- Arterial pressure usually decreases to a nadir at 24 to 26 weeks and rises thereafter.
- venous blood flow in the legs is retarded during pregnancy due to occlusion of the pelvic veins and inferior vena cava by the enlarged uterus → the elevated venous pressure returns to normal when the pregnant woman lies on her side and immediately after delivery
  - → these alterations contribute to the dependent bipedal edema, varicose veins in the legs and vulva, and hemorrhoids that may predispose to deep-vein thrombosis during pregnancy

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Supine Hypotension

- supine compression of the great vessels by the uterus causes significant arterial hypotension, sometimes referred to as the ***supine hypotensive syndrome***
- when supine, uterine arterial pressure—and thus blood flow—is significantly lower than that in the brachial artery.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Renin, Angiotensin II, and Plasma Volume

- All components of the Renin-Angiotensin-Aldosterone system are increased in normal pregnancy
  - → Renin is produced by both the maternal kidney and the placenta, and increased renin substrate (angiotensinogen) is produced by both maternal and fetal liver.
  - → Elevated angiotensinogen levels result, in part, from increased estrogen production during normal pregnancy

- Normal normotensive pregnant women are ***"angiotensin resistant"*** (became and stayed refractory to the pressor effects of infused angiotensin II)

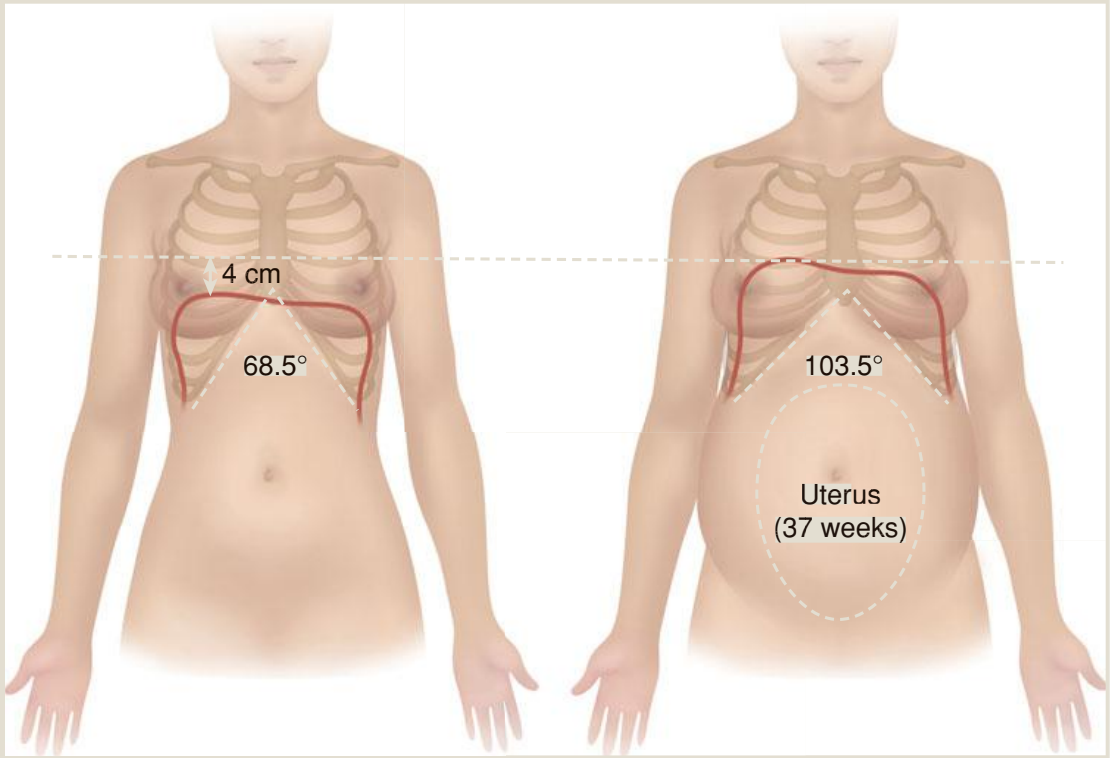
- Conversely, those who ultimately became hypertensive lost this refractoriness..

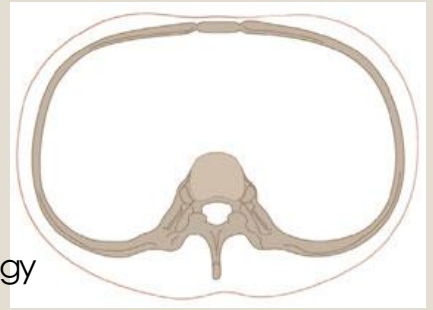
  - Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

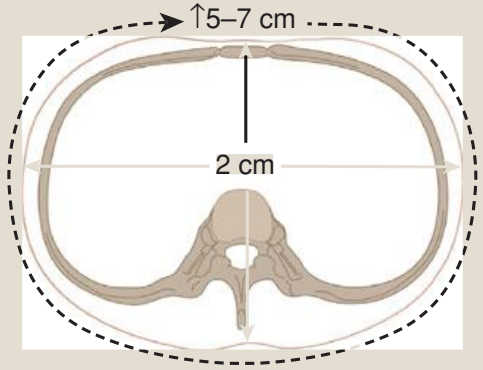
RESPIRATORY TRACT

Chest wall

- subcostal angle increases, as does the anteroposterior and transverse diameters of the chest wall and chest wall circumference.
- These changes compensate for the 4-cm elevation of the diaphragm so that total lung capacity is not significantly reduced





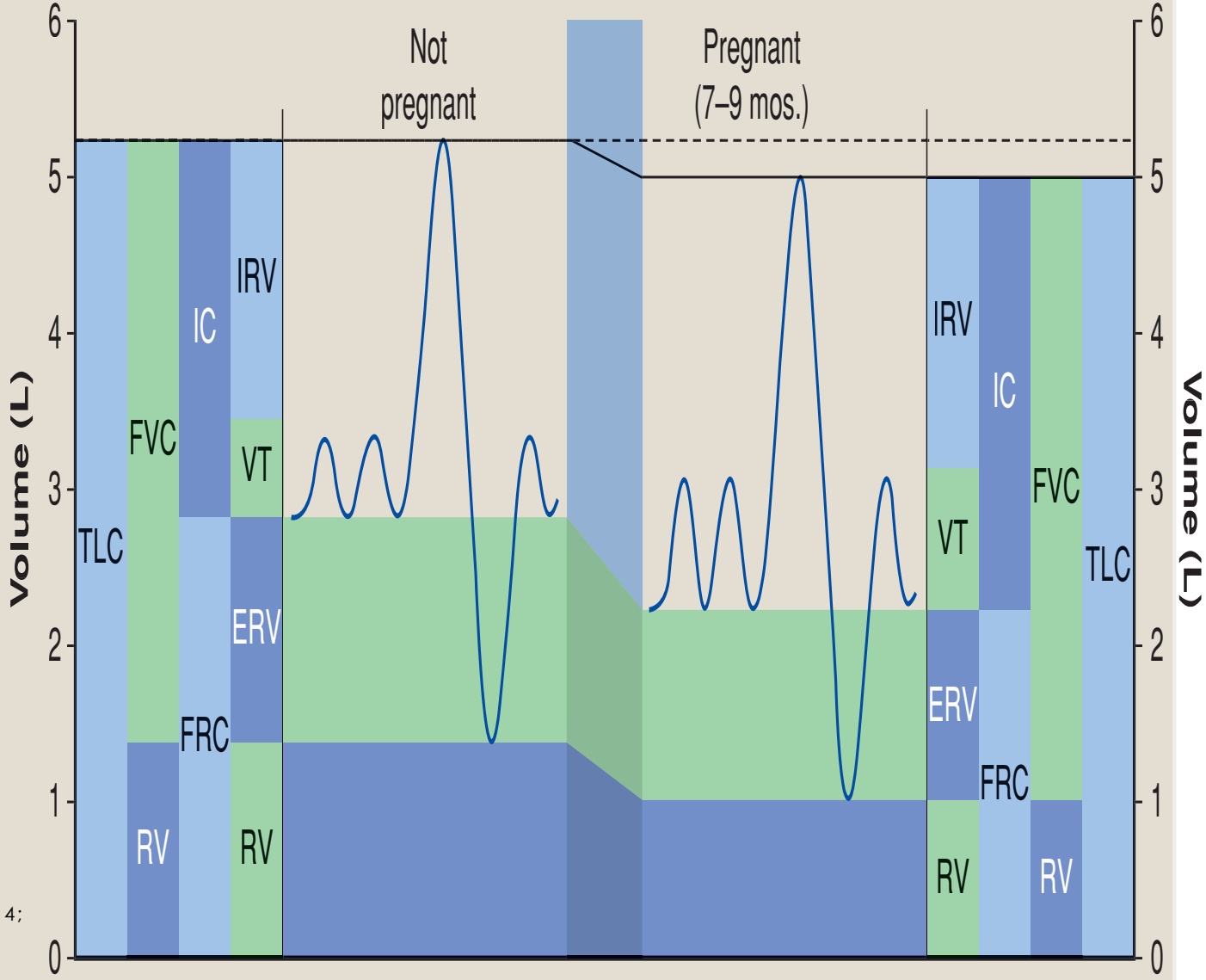


- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Pulmonary function

The most significant changes are:

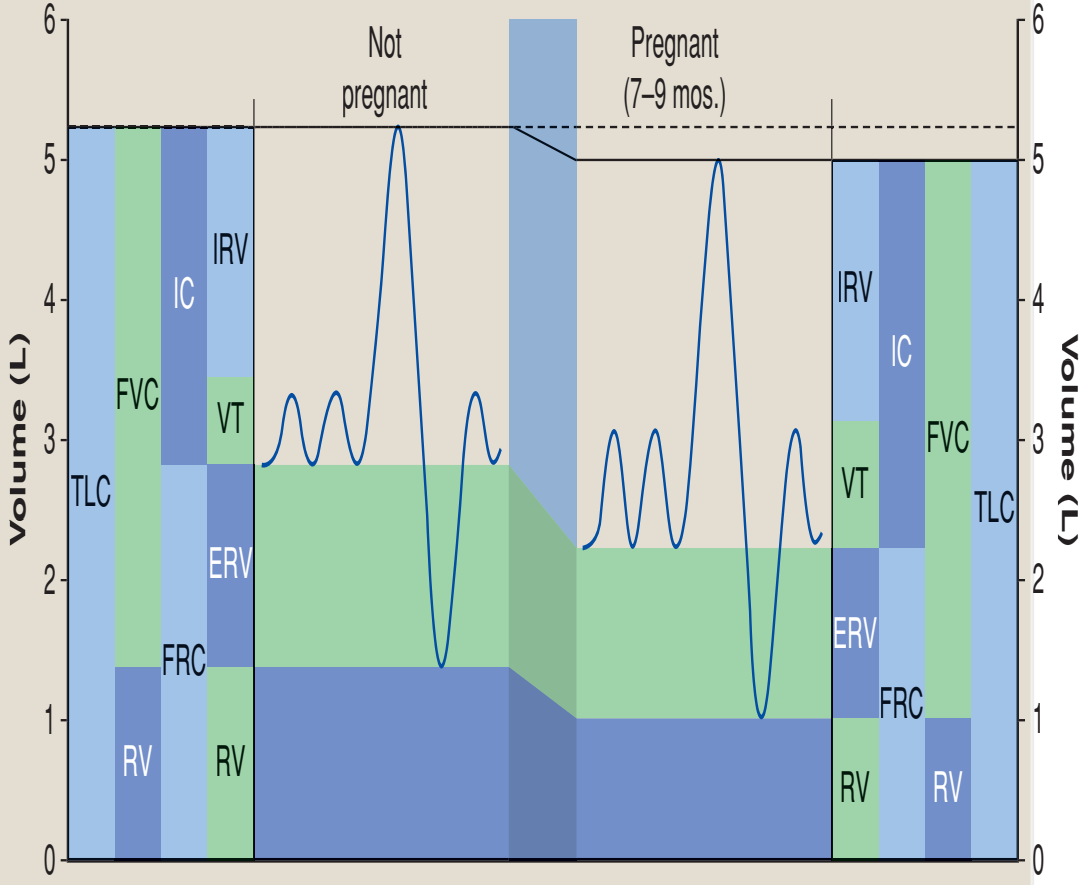
1) reduction in functional residual capacity (FRC) expiratory reserve volume (ERV) and residual volume (RV)
2) increases in inspiratory capacity (IC) and tidal volume (VT).



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Pulmonary function

- Increased minute ventilation is caused by several factors:
  1. enhanced respiratory drive primarily due to the stimulatory action of progesterone
  2. low expiratory reserve volume
  3. compensated respiratory alkalosis



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Acid–Base Equilibrium

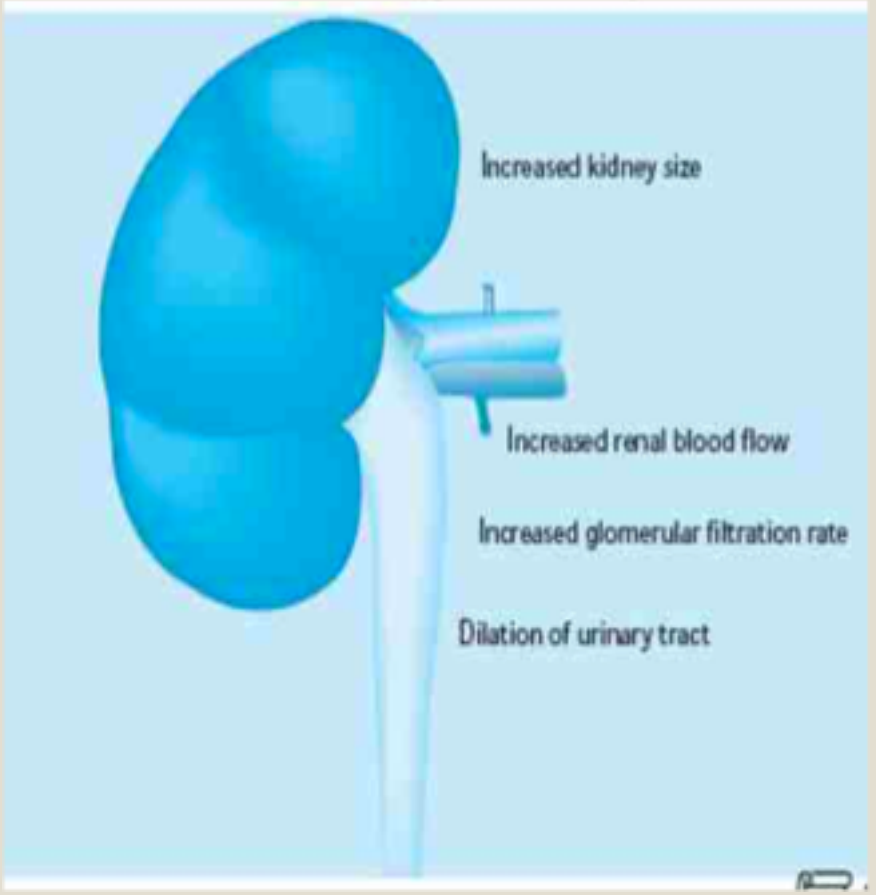
- "***Physiological dyspnea***" - An increased awareness of a desire to breathe which should not interfere with normal physical activity
  - result from increased tidal volume that lowers the blood Pco2 slightly and paradoxically causes dyspnea.
  - increased respiratory effort during pregnancy, and in turn the reduction in Pco2, is likely induced in large part by progesterone and to a lesser degree by estrogen.
  - Progesterone appears to act centrally, where it lowers the threshold and increases the sensitivity of the chemoreflex response to CO2

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

URINARY SYSTEM

Kidney

- Kidney size increases approximately 1.5 cm
- GFR and renal plasma flow increase early in pregnancy → result from two principal factors:
  1. hypervolemia-induced hemodilution lowers the protein concentration and oncotic pressure of plasma entering the glomerular microcirculation.
  2. renal plasma flow increases by approximately 80 percent before the end of the first trimester
  - as a consequence of this elevated GFR, pregnant women report urinary frequency during pregnancy



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Renal Function Tests

- Serum creatinine levels decrease during normal pregnancy from a mean of 0.7 to 0.5 mg/dL → Values of 0.9 mg/dL or greater suggest underlying renal disease and should prompt further evaluation.
- Creatinine clearance increases
- During the day, pregnant women tend to accumulate water as dependent edema, and at night, while recumbent, they mobilize this fluid with diuresis.
  - → causes nocturia, and urine is more dilute than in nonpregnant women.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

urinalysis

- **Glucosuria** during pregnancy may not be abnormal due to increase in GFR, together with impaired tubular reabsorptive capacity for filtered glucose, BUT when glucosuria is identified, the possibility of diabetes mellitus should not be ignored.

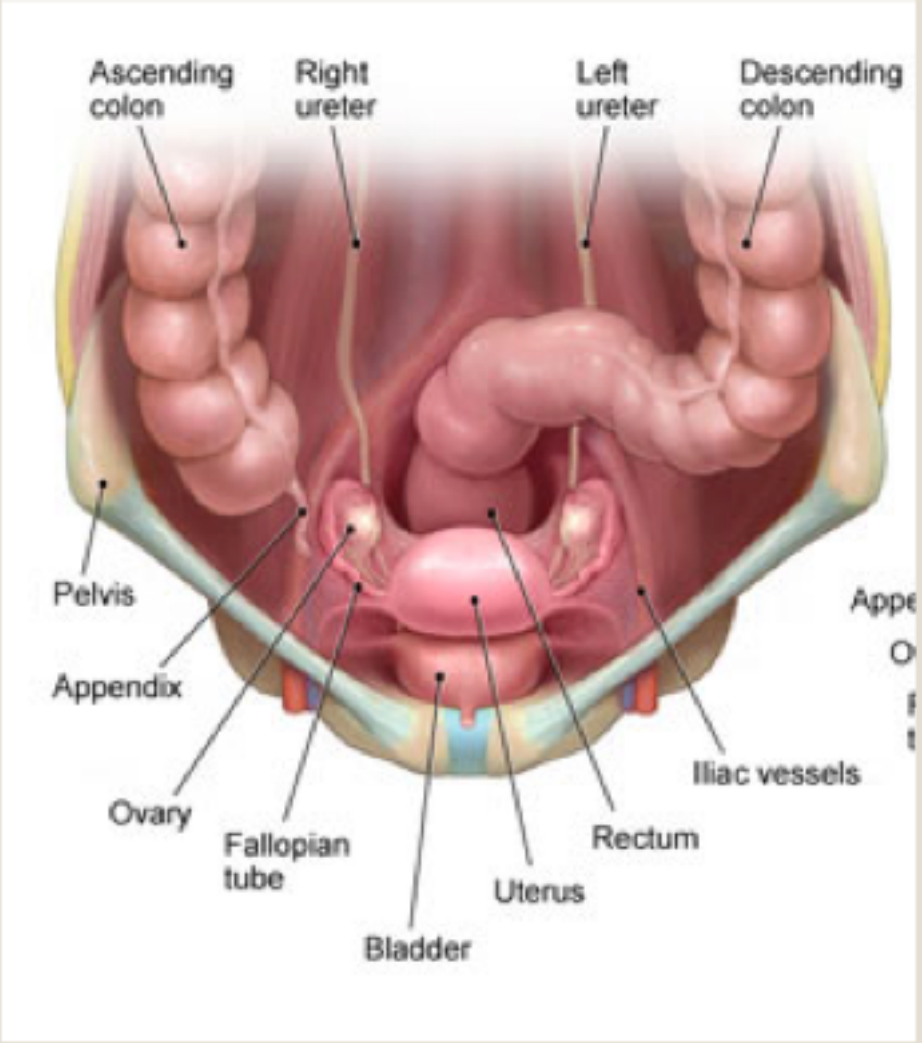
- **Hematuria** most often suggests urinary tract disease. Hematuria is common after difficult labor and delivery because of trauma to the bladder and urethra.

- Significant proteinuria is defined as a protein excretion rate of **at least 300 mg/day**

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Ureters

- Enlarged uterus rests on the ureters, which laterally displaces and compresses them at the pelvic brim → Ureteral dilatation found to be greater on the right side in 86 percent of women:
  1. Unequal dilatation may result from cushioning of the left ureter by the sigmoid colon and/or from greater right ureteral compression exerted by the dextrorotated uterus.
  2. right ovarian vein complex lies obliquely over the right ureter and may contribute significantly to right ureteral dilatation.



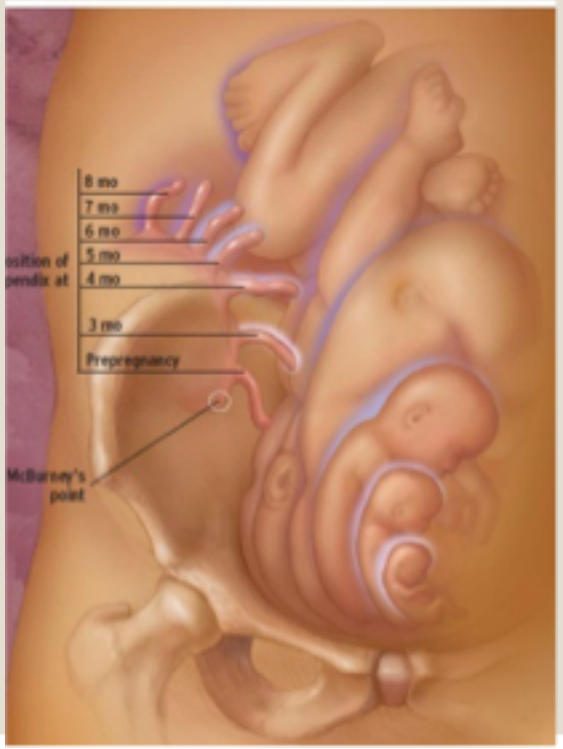
- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

GASTROINTESTINAL TRACT

GI tract

- **Pregnancy gingivitis** → gums may become hyperemic and softened and may bleed when mildly traumatized; regresses spontaneously after delivery.

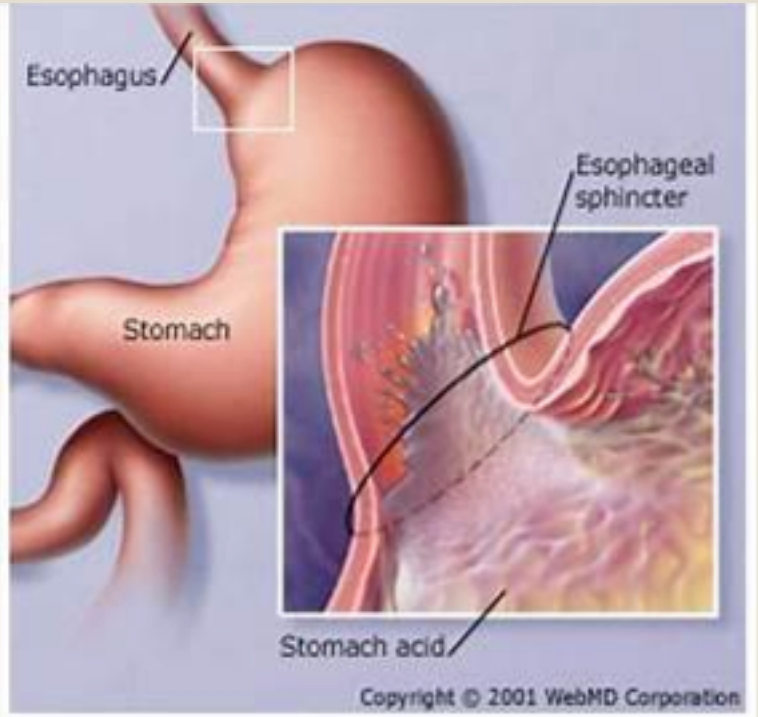
- Abdominal PE findings in certain diseases are altered (as the stomach and intestines are displaced by the enlarging uterus)
  - appendix, for instance, is usually displaced upward and somewhat laterally as the uterus enlarges.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

GI tract

- **Pyrosis (heartburn)** is caused by reflux of acidic secretions into the lower esophagus:
  1. altered stomach position
  2. esophageal sphincter tone is decreased.
  3. intraesophageal pressures are lower and intragastric pressures higher in pregnant women.
  4. Decreased esophageal peristalsis secondary to progesterone effect

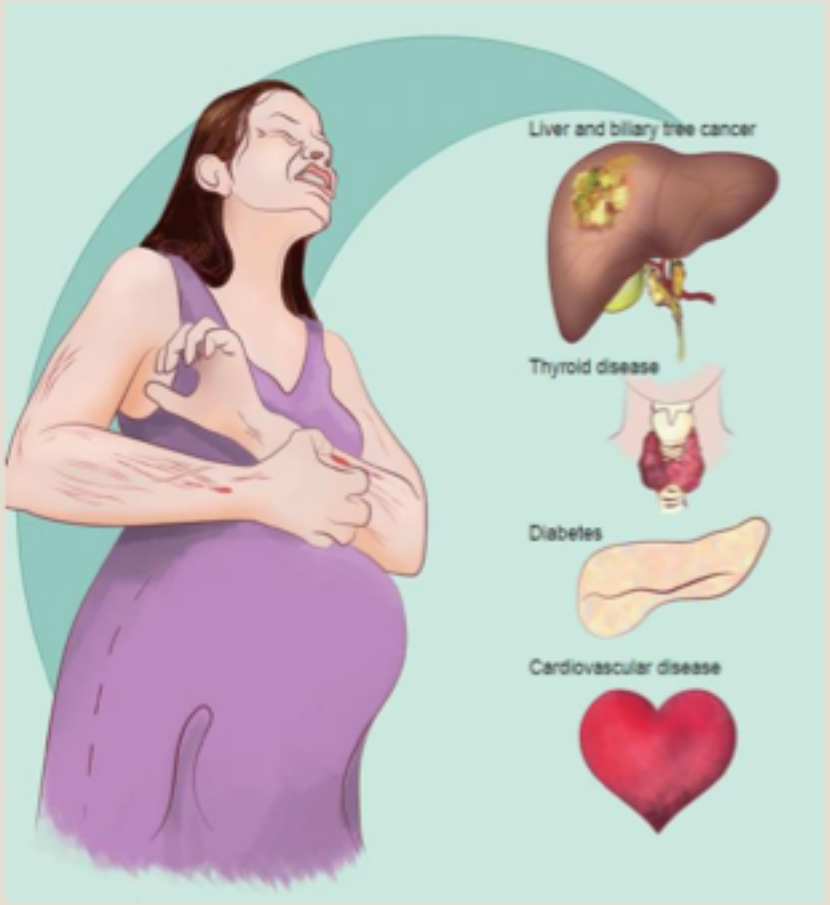


- Hemorrhoids are caused by constipation and elevated pressure in veins below the level of the enlarged uterus.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Gallbladder

- Progesterone impairs gallbladder contraction by inhibiting cholecystokinin-mediated smooth muscle stimulation (primary regulator of gallbladder contraction)
- Impaired emptying, subsequent stasis, and an increased bile cholesterol saturation of pregnancy contribute to the increased prevalence of cholesterol gallstones in multiparas (***Cholestasis of pregnancy***)



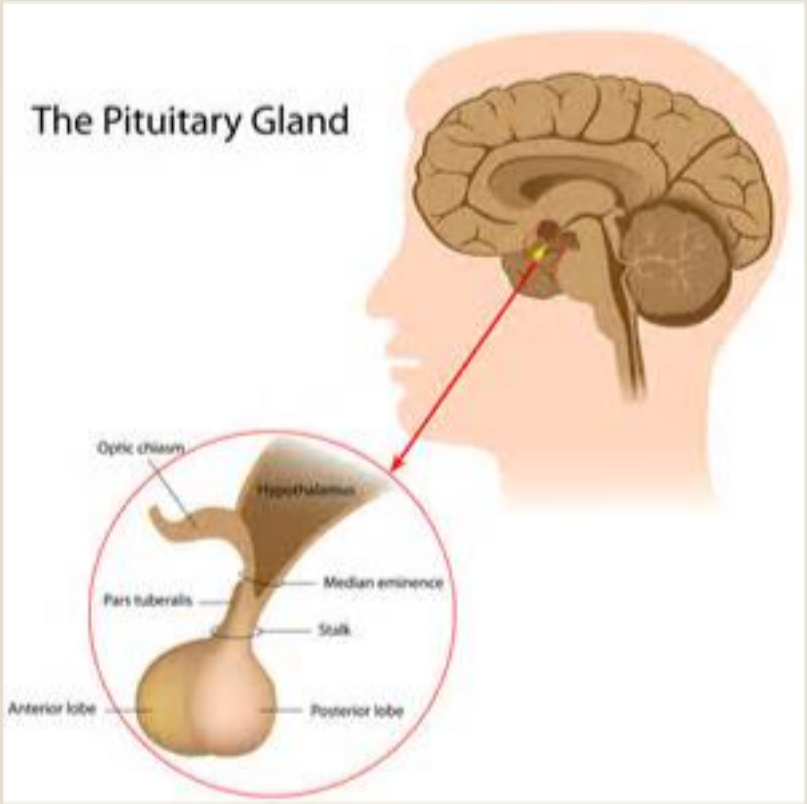
- **pruritus gravidarum** from retained bile salts.
- Intrahepatic cholestasis has been linked to high circulating levels of estrogen

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

ENDOCRINE SYSTEM

Pituitary gland

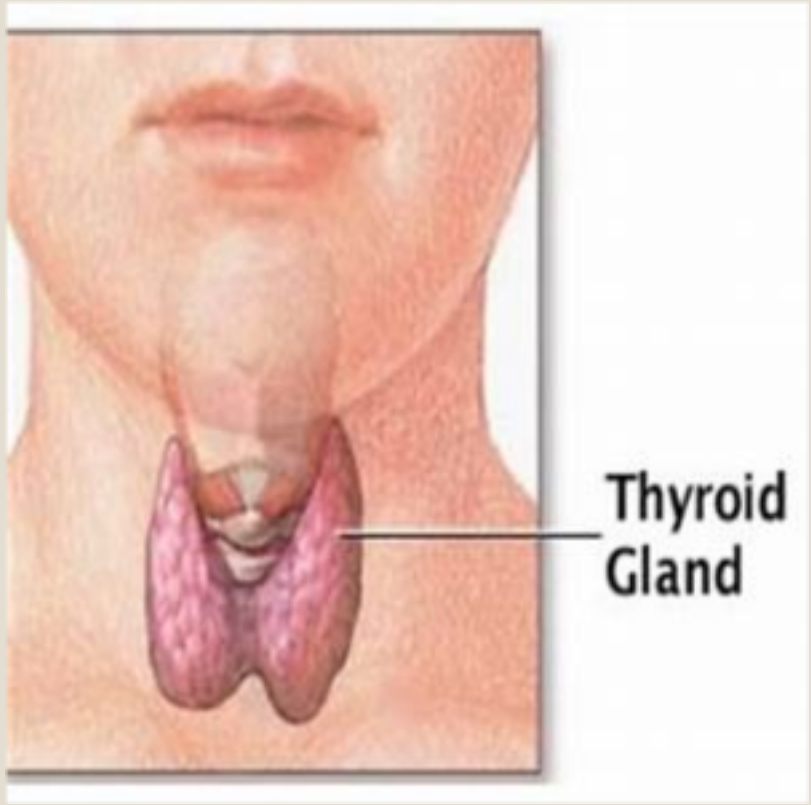
- pituitary gland enlarges by approximately 135 percent (primarily caused by estrogen-stimulated hypertrophy and hyperplasia of the lactotrophs) → increase in prolactin
- gland involutes rapidly thereafter and reaches normal size by 6 months postpartum
- maternal pituitary gland is **not essential** for pregnancy maintenance
  - Many women have undergone hypophysectomy, completed pregnancy successfully, and entered spontaneous labor while receiving compensatory glucocorticoids, thyroid hormone, and vasopressin



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

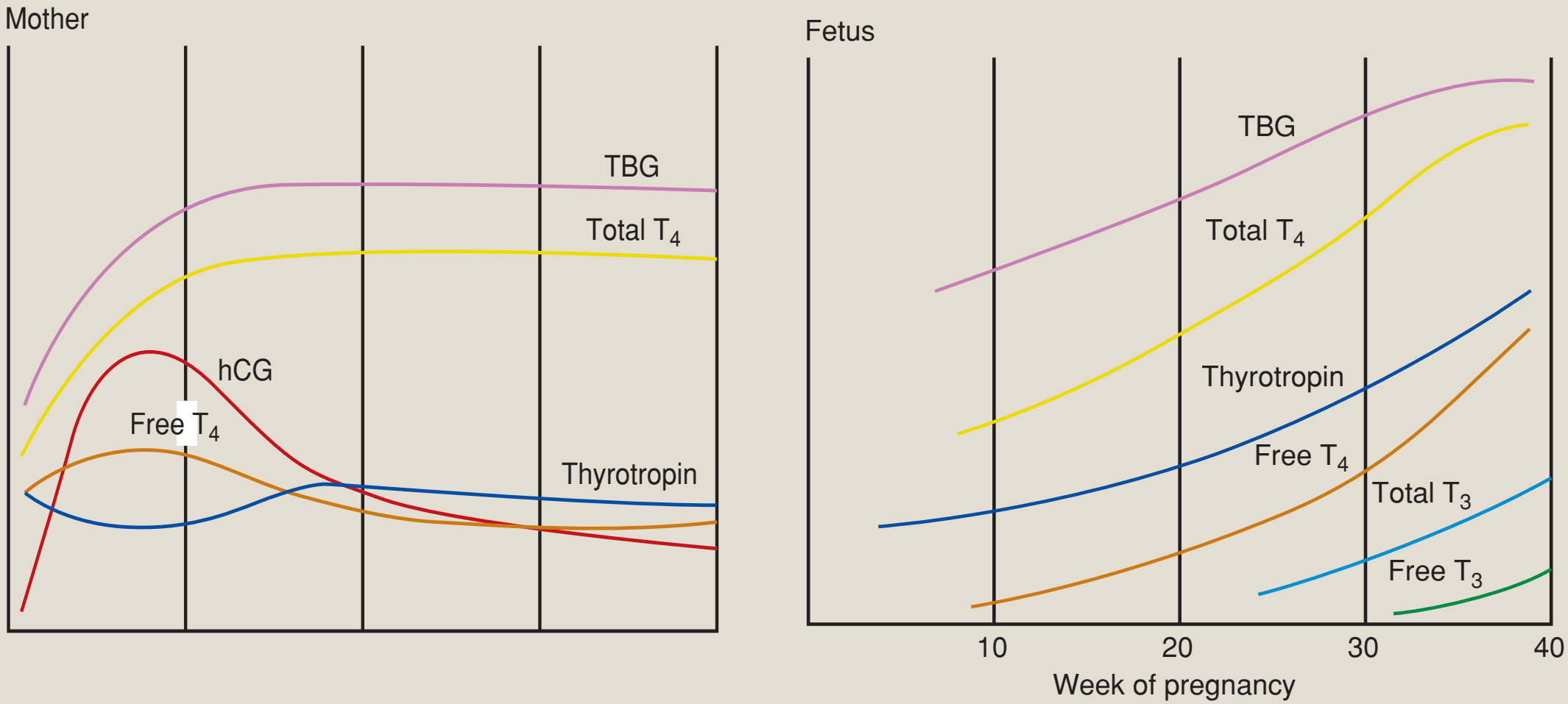
Thyroid gland

- thyroid gland undergoes moderate enlargement during pregnancy caused by glandular hyperplasia and increased vascularity.
  - normal pregnancy does not typically cause significant thyromegaly → thus any goiter should be investigated.



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Thyroid function



- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Iodine Status

- Iodine requirements increase during normal pregnancy.
- In women with low or marginal intake, deficiency may manifest as low thyroxine and increased TSH levels.
- For the fetus, early exposure to thyroid hormone is essential for the nervous system
- Severe deficiency leads to cretinism.

- Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, Casey BM, Sheffield JS (eds).William's Obstetrics 24th edition; 2014; chapter 4; Maternal physiology

Outline

1. REPRODUCTIVE TRACT
2. BREASTS
3. SKIN
4. METABOLIC CHANGES
5. HEMATOLOGICAL CHANGES
6. CARDIOVASCULAR SYSTEM
7. RESPIRATORY TRACT
8. URINARY SYSTEM
9. GASTROINTESTINAL TRACT
10. ENDOCRINE SYSTEM

Thank you!

youtube channel: Ina Irabon

www.wordpress.com: Doc Ina OB Gyne