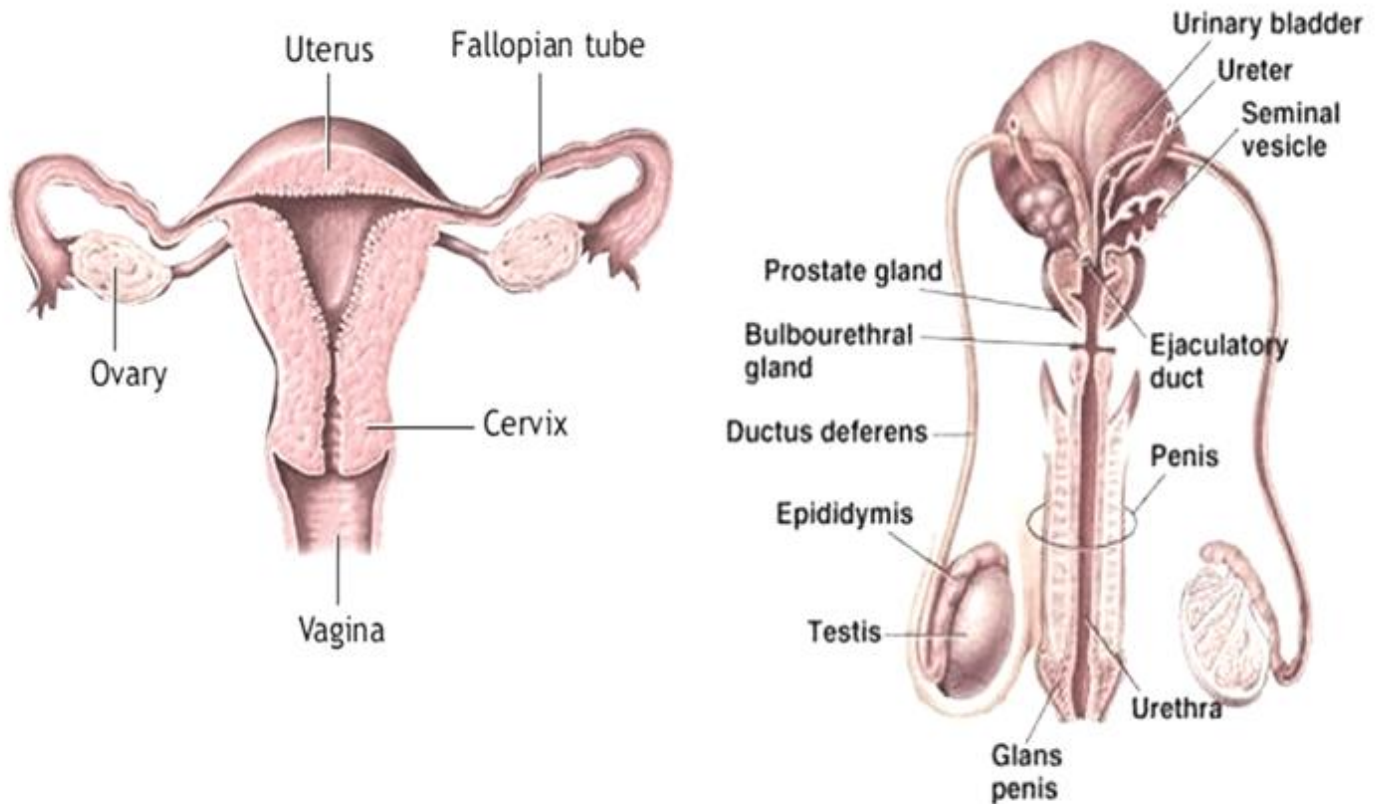


6th Lecture

Physiology of Pregnancy



PHYSIOLOGY TEAM – 430

This Lecture is done by:

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Layan Akkielah**

This lecture is divided into two parts:

1- Embryology Part

2- Physiology Part

The male's doctor said the Embryology part is for reading ☺

Organized by: Al-Waleed Al-Johar

Physiology of Pregnancy (Embryology part)

- **Fertilization:**

- After ejaculation sperms reach **ampulla** of fallopian tube within 30-60 min
- Sperm penetrate **corona radiata** and **zona pellucida** (by **hyaluronidase**)
- **Oocyte divides** to form **mature ovum** (female pronucleus 23 unpaired chromosomes) + **2nd polar body**
- Head of sperm **swells** (male pronucleus 23 unpaired chromosomes)
- Fertilized ovum (zygote) contain 23 paired chromosomes

- **Cleavage:**

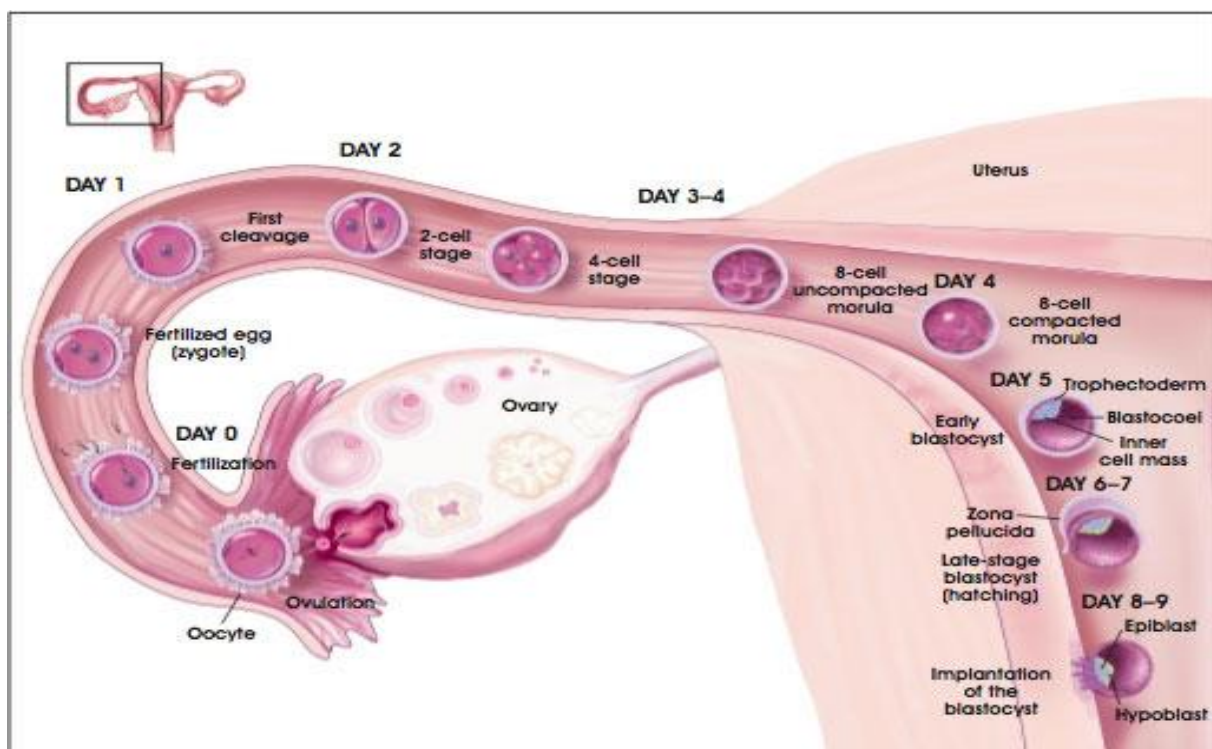
- Following fertilization the zygote undergoes several **mitotic divisions** inside the **zona pellucida** (overall **size does not change**)
- **1st** cleavage yields a **2 celled embryo**, each cell is called a **blastomere** and is totipotent
- Divisions continue rapidly until the **32 cell stage**

- **Traveling:**

- **Zygote** begins to divide as it travels through **oviduct**
- **Implants** into lining of **uterus**

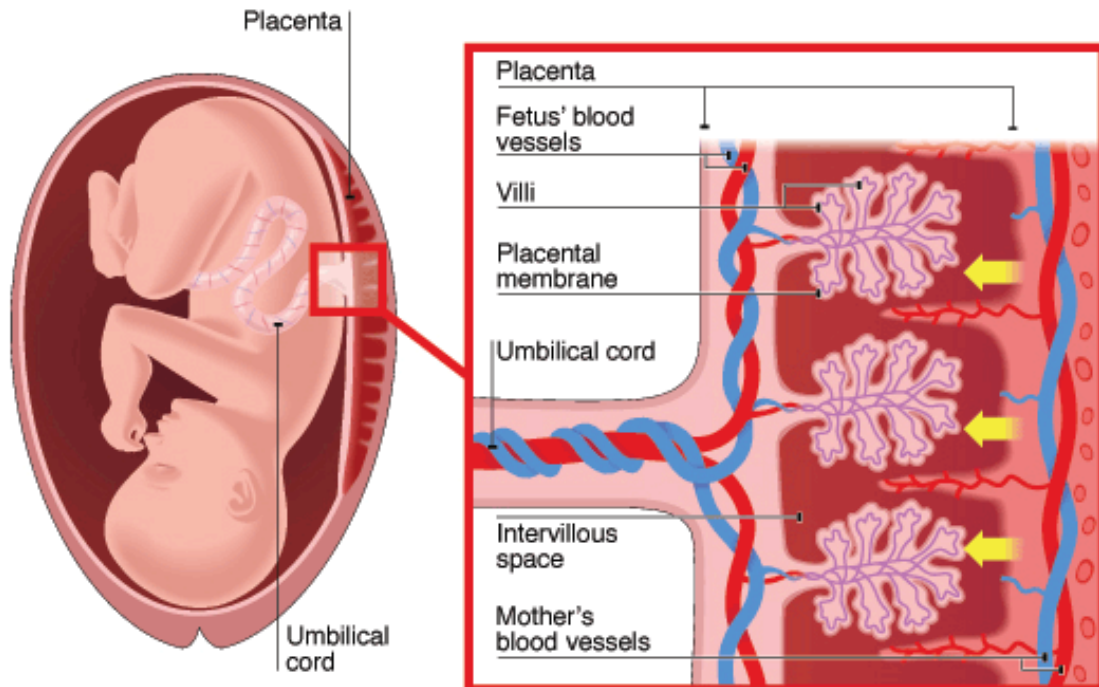
- **Transport of fertilized ovum:**

- After fertilization **3-5 days** till zygote reach **uterine cavity**
- Transport: fluid **current** + action of **cilia** + weak **contractions** of the **fallopian tube**
- Isthmus (last 2cm) **relaxes** under effect of **progesterone**
- **Delayed** transport allows **cell division**
- **Blastocyst** (100 cells) enters the **uterus**



- **Placenta:**

- Trophoblastic cords from blastocyst
- Blood capillaries grow in the cords
- 21 days after fertilization blood start to be pumped by fetal heart into the capillaries
- Maternal blood sinuses develop around the trophoblastic cords
- More and more trophoblast projections develop (placental villi)



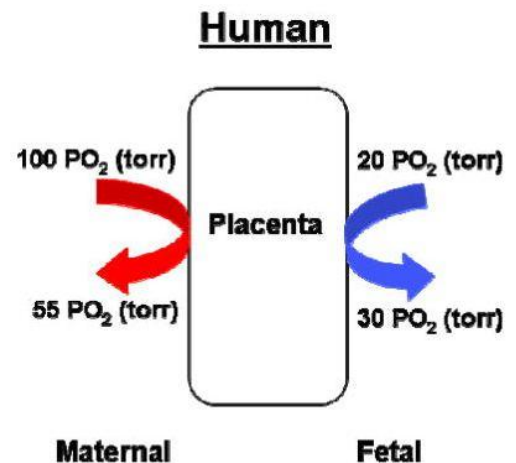
Physiology of Pregnancy (Physiology part)

• Function of the placenta:

1. Respiration
2. Nutrition
3. Excretion
4. Endocrine
5. Protection

1) Respiration:

- PCO_2 2-3 mm Hg **higher in fetal** than maternal blood
- Dissolved O_2 in mother's blood passes to fetal blood by **simple diffusion**
- PO_2 50 mm Hg (Maternal) - 30 mm Hg (Fetal) = 20 mmHg
- At low PO_2 **HbF** carry **20-50% more O_2** than **HbA** (HbF has a higher oxygen carrying capacity than HbA)
- **Hb** in fetus (all types of Hb) concentration **50% higher** than Hb in mother
- **Double Bohr effect:**
 - ✓ Low pH in **mother's** blood (**acidic**)
 - ✓ High pH in **fetal** blood (**alkaline**)

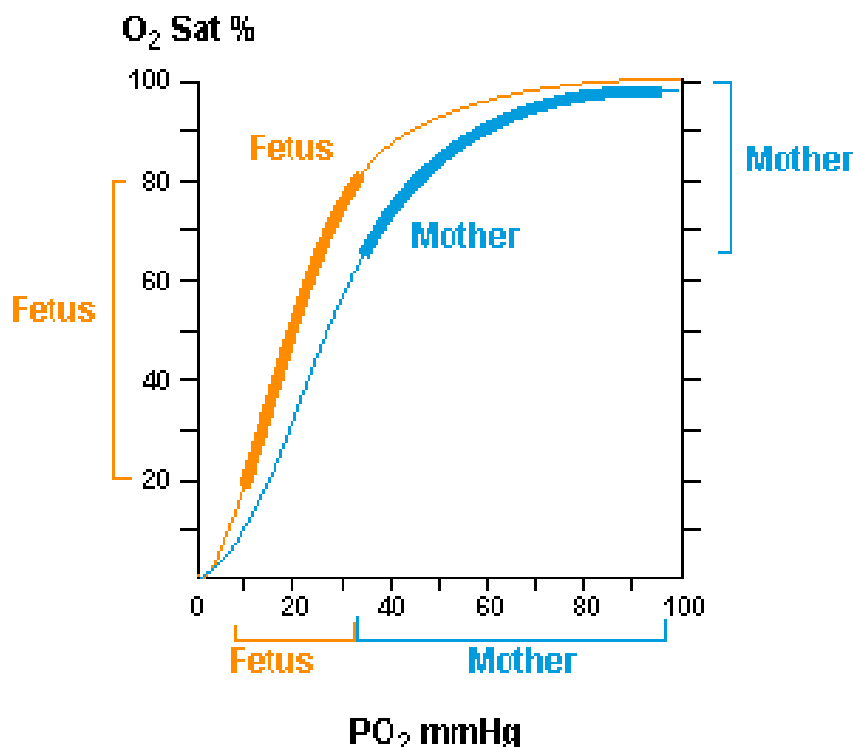


The maternal PO_2 which reaches the placenta is 50 mm Hg, and fetal is 30 mm Hg, so the fetus will take 20 mm Hg by simple diffusion

The lesser the pH \rightarrow the lesser of O_2 affinity, so the mother will lose and the fetus will take

• Important shifts of the dissociation curves take place in the placenta:

- ✓ The **maternal** blood **gains CO_2** (which is acidic), the **pH falls** and the curve **shifts to the right** releasing additional oxygen.
- ✓ On the **fetal** side of the placenta **CO_2 is lost**, the **pH rises** and the curve **shifts to the left** allowing additional oxygen uptake.



- **Important factors facilitate delivery of oxygen to the fetal tissues:**

- High **maternal intervillous blood flow** (almost double the fetal placental flow)
- High fetal **haemoglobin** (16 - 17 g/dl)
- High fetal **cardiac output**
- The fetal **metabolic acidosis** which shifts the curve to the right and thus aids **delivery of oxygen** to the tissues.

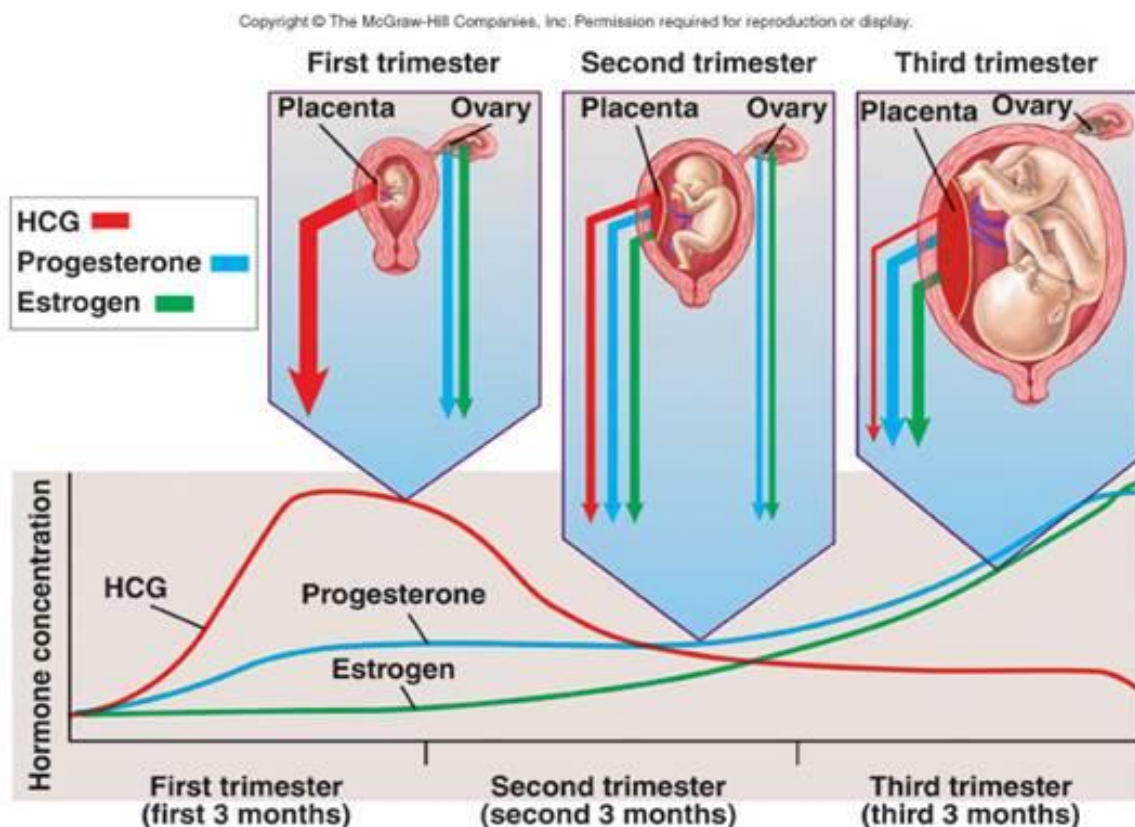
2) Nutrition:

- Fetus uses mainly **glucose** for nutrition so the trophoblast cells in placental villi transport glucose by carrier molecules; **GLUT** (facilitated diffusion)
- **Fatty acids** diffuses due to high solubility in cell membrane (more slowly than glucose)
- The **placenta** actively **transports all amino acids**, with fetal concentrations exceeding maternal levels.
- **K⁺, Na⁺ and Cl⁻** diffuses from maternal to fetal blood

3) Excretion:

- **Excretory products** of the fetus diffuse through **placental membrane** to **maternal blood** to be excreted with waste products of the mother (e.g. Urea, uric acid and creatinine)
- **Higher conc.** of excretory products in fetal blood insures **continuous diffusion** of these substances to the maternal blood

4) Endocrine:



- **Human Chorionic Gonadotropin (hCG):**

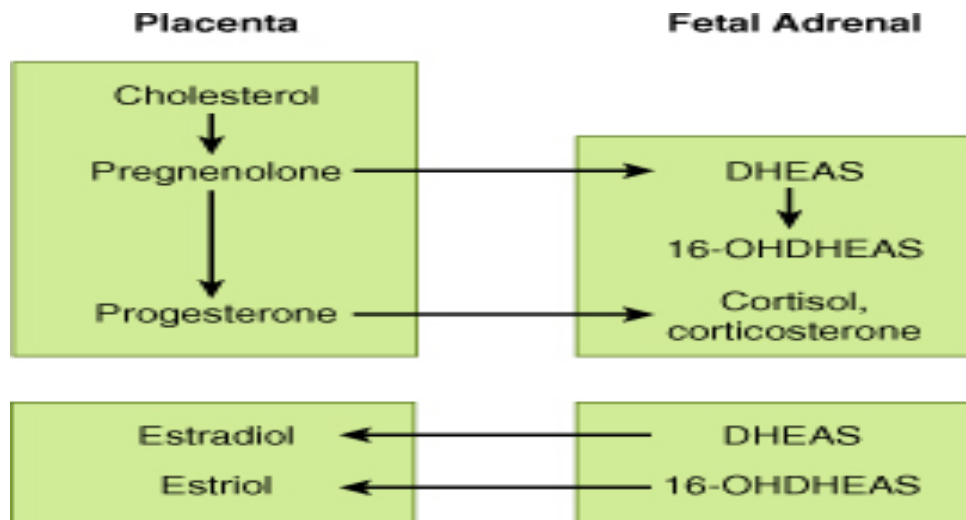
- **Glycoprotein** (same as LH, FSH, & TSH. All four hormones share the same α -subunit but β differs)
- Most important function is to **maintain corpus luteum** (\uparrow estrogen & progesterone) till 13-17 weeks of gestation
- **Exerts interstitial** (Leyding) **cell-stimulating effect** on testes of the male fetus (growth of male sex organs)
- **Functions of hCG:**
 1. Produced by **syncytiotrophoblasts** (8-9 d after fertilization)
 2. **Maintains corpus luteum** beyond normal lifespan
 3. **Stimulates progesterone and Estrogen** by Corpus luteum
 4. **Stimulates essential DHEA-S** in fetal zone of adrenal gland
 5. **Stimulates testosterone production** in male fetus (for sex differentiation)
 6. **Inhibit contractions** produced by **oxytocin** in the **uterus**
 7. **Immunosuppressant** (that's because the fetus is considered a foreign body for the mother)
 8. **Stimulates the growth of the fetus** (it is considered the most important hormone affecting growth)

- **Estrogen:**

- **Steroid hormone**
- Secreted by **syncytial trophoblast** cells
- Towards end of pregnancy reaches **30 \times**
- **Derived** from weak androgen (**DHEA**) **released** from maternal & fetal **adrenals**
- **Functions in the mother:**
 - ✓ **Enlargement of uterus, breast & external genitalia**
 - ✓ **Relaxation of pelvic ligaments** in preparation to labor
 - ✓ **Activation of the uterus** (gap junctions)
 - ✓ **Increase oxytocin receptors** for uterine contraction later when **delivery approaches**

- **Interactions between placenta and fetal adrenal cortex in the production of steroids:**

- **Fetus:** **deficient in 3 β -hydroxysteroid dehydrogenase**, so the fetus has to obtain pregnenolone & progesterone from placenta, then it will change **Pregnenolone to DHEA-S** (precursor of estrogen) and also will change **Progesterone to gluco/mineralocorticoids** by its **adrenal cortex** which is way **bigger** than the normal adult cortex.
- Fetus will **use gluco/mineralocorticoids**, while it will **return** back **DHEA-S** to the mother for the formation of **estrogen** (this is the main source of estrogen after 2-4 months of pregnancy "because there's no more corpus luteum")
- **Placenta:** placenta **can't synthesize gluco/mineralocorticoids** because it **lacks 3 α -hydroxylase**, so it **can't metabolize** progesterone
- Therefore, gives **progesterone** back to **fetus** to make **gluco/mineralocorticoids**



- **Estradiol:**

- Initially produced by corpus luteum (first 5-6 wks)
- Stimulated by hCG at first, then placenta (from DHEA-S from fetus)
- Increase uterine blood flow
- If it's excreted in urine → index of fetal well-being (because the fetus gives the precursor for the estrogen, so estrogen in urine means fetus is ok)

- **Progesterone:**

- Steroid hormone
- Secreted by syncytial trophoblast cells
- Towards end of pregnancy reaches 10×
- Derived from cholesterol
- **Functions in the mother:**
 - ✓ Provides nutrition to developing embryo (because of its secretory functions)
 - ✓ Development of decidual cells
 - ✓ Inhibit the contractility of the uterus

- **Human Chorionic Somatomamotropin:**

- Protein hormone
- Secreted by placenta around 5th gestational week
- **Functions in the mother:**
 - ✓ Breast development (hPL "human placental lactogen")
 - ✓ Weak growth hormone's action
 - ✓ Inhibit insulin sensitivity = ↓ glucose utilization (therefore causing lipolysis "anti-insulin")
 - ✓ Promote release of fatty acids

- **Relaxin:**

- Polypeptide
- Secreted by corpus luteum and placenta
- **Functions in the mother:**
 - ✓ Relaxation of symphysis pubic ligament "weak" (which is helpful in delivery)
 - ✓ Softens the cervix at delivery

- **Physiological adaptation to pregnancy:**

- ☒ **Changes in maternal endocrine system:**

- ✓ **Anterior pituitary gland enlargement (50%)**

- Release of **ACTH**, **TSH** and **Prolactin** increase
- **FSH** and **LH** almost totally **suppressed**

- ✓ **Adrenal gland**

- **Increase glucocorticoids** secretion (mobilize aa)
- **Increase aldosterone** (retain fluid)

- ✓ **Thyroid gland enlargement (50%)**

- **Increase thyroxine** production (hCG)

- ✓ **Parathyroid gland enlargement**

- **Increase PTH** secretion (maintain normal Ca^{+2})

- ☒ **Changes in different organs:**

- ✓ **Increase in uterine size** (50 gm to 1100 gm)

- ✓ The **breasts** double in size

- ✓ The **vagina** enlarges

- ✓ Development of **edema and acne** (acne because of the increased androgens)

- ✓ Masculine or **acromegalic features**

- ✓ **Weight gain** 10-12 kg (last 2 trimesters):

Because of the **increased appetite** which is due to **removal of food** by fetus & **hormonal effects**

- ☒ **Changes in metabolism:**

- ✓ **Increase basal metabolic rate** (15%)

- ✓ **Increase in daily requirements** for **Iron**, **Phosphates**, **Calcium**, **Vitamins** (e.g. Vitamin D " for Ca^{+2} absorption")

- ☒ **Changes in circulatory system:**

- ✓ **Increase in cardiac output** (30-40%) by 27 weeks

- ✓ **Increase in blood flow** through the **placenta**

- ✓ **Increase in maternal blood volume** (30%) due to:

- **Increase aldosterone** and **estrogen** (\uparrow ECF)
- **Increase activity of the bone marrow** (\uparrow RBCs)

- ☒ **Changes in respiration:**

- ✓ **Increase in O_2 consumption** (20%): because **BMR** & **body size** are **increased**

- ✓ Growing **uterus** presses upwards (restriction \rightarrow **tightness of chest**)

- ✓ **Increase in respiratory rate**

- ✓ **Increase in minute ventilation** (Tidal Volume \times Respiratory Rate) by 50%

- **Progesterone** \uparrow sensitivity of respiratory center to CO_2