Physiology of pregnancy

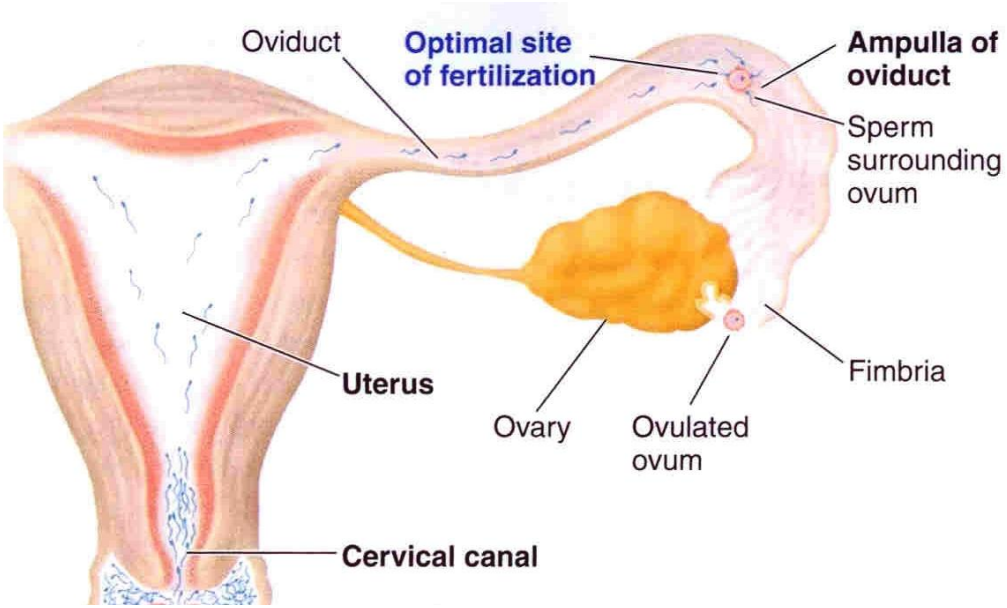
DR. HANA ALZAMIL

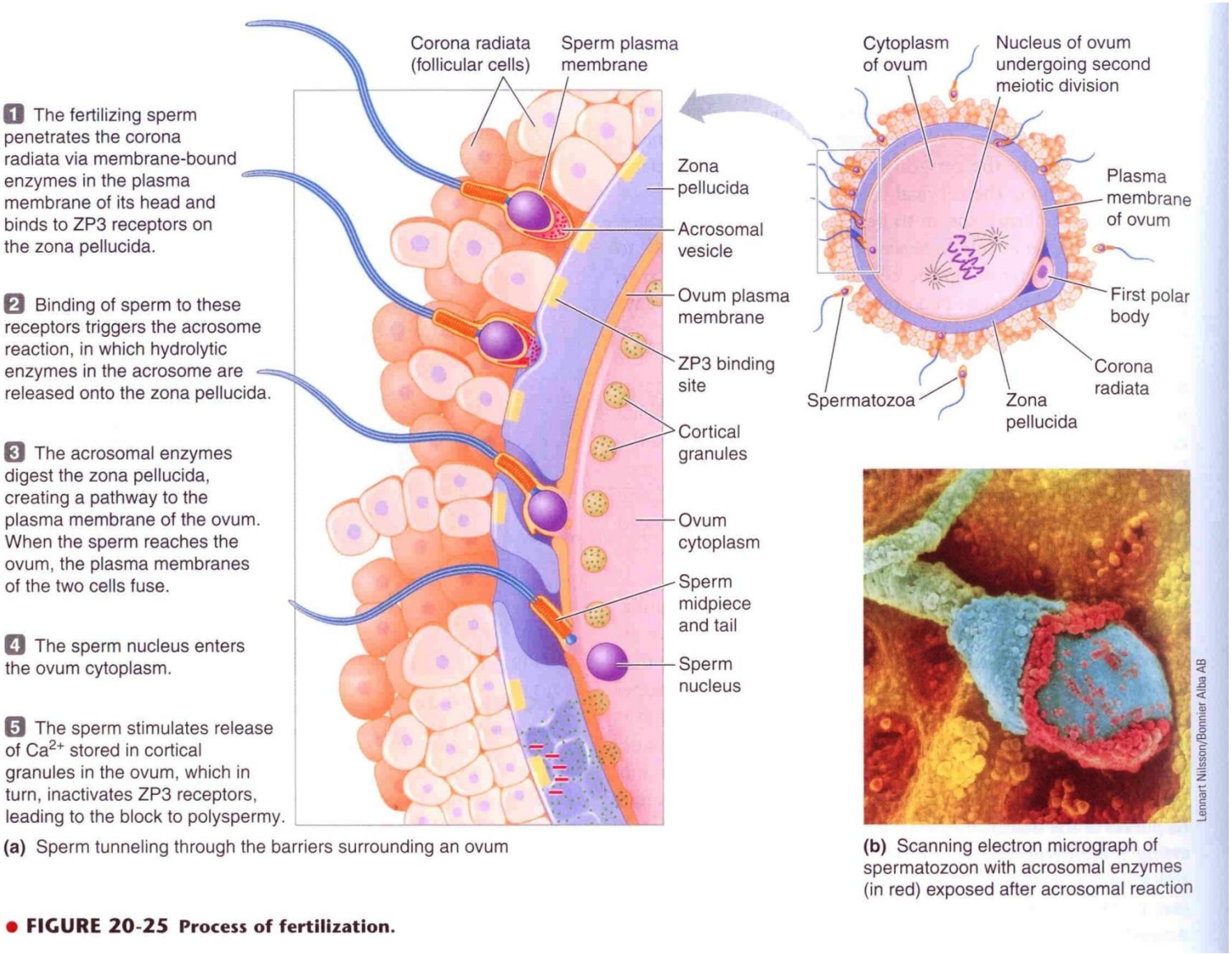
Objectives

- Fertilization
- Development and function of the placenta
- Placenta as an endocrine organ
- Physiological functions of placental hormones
- Maternal adaptation to pregnancy

Fertilization

Location	Time of appearance (min after ejaculation)	Percent of ejaculated sperm*
Fertilization site (upper third of oviduct)	30–60	0.001
Uterus	10–20	0.1
Cervical canal	1–3	3





(a) Sperm tunneling through the barriers surrounding an ovum

(b) Scanning electron micrograph of spermatozoon with acrosomal enzymes (in red) exposed after acrosomal reaction

● **FIGURE 20-25 Process of fertilization.**

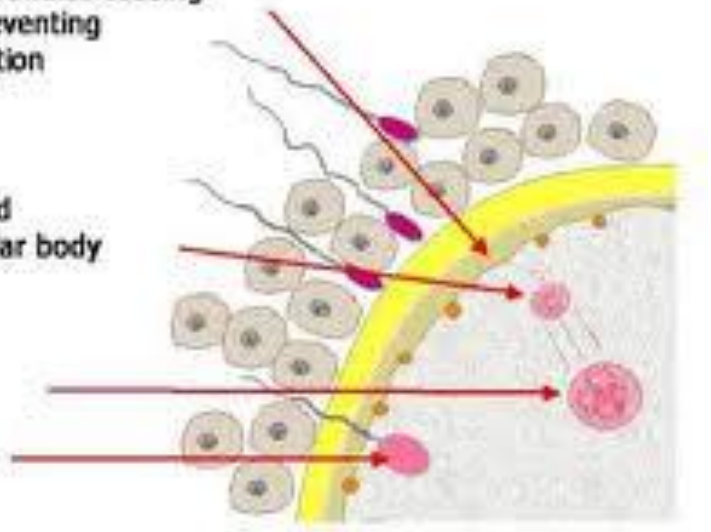
Fertilization

1. release of cortical granules causing the zona reaction, preventing further sperm penetration

2. completion of the 2nd meiotic division and extrusion of the 2nd polar body

3. formation of female pronucleus

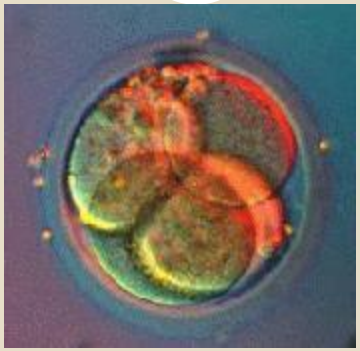
male pronucleus



Fertilization

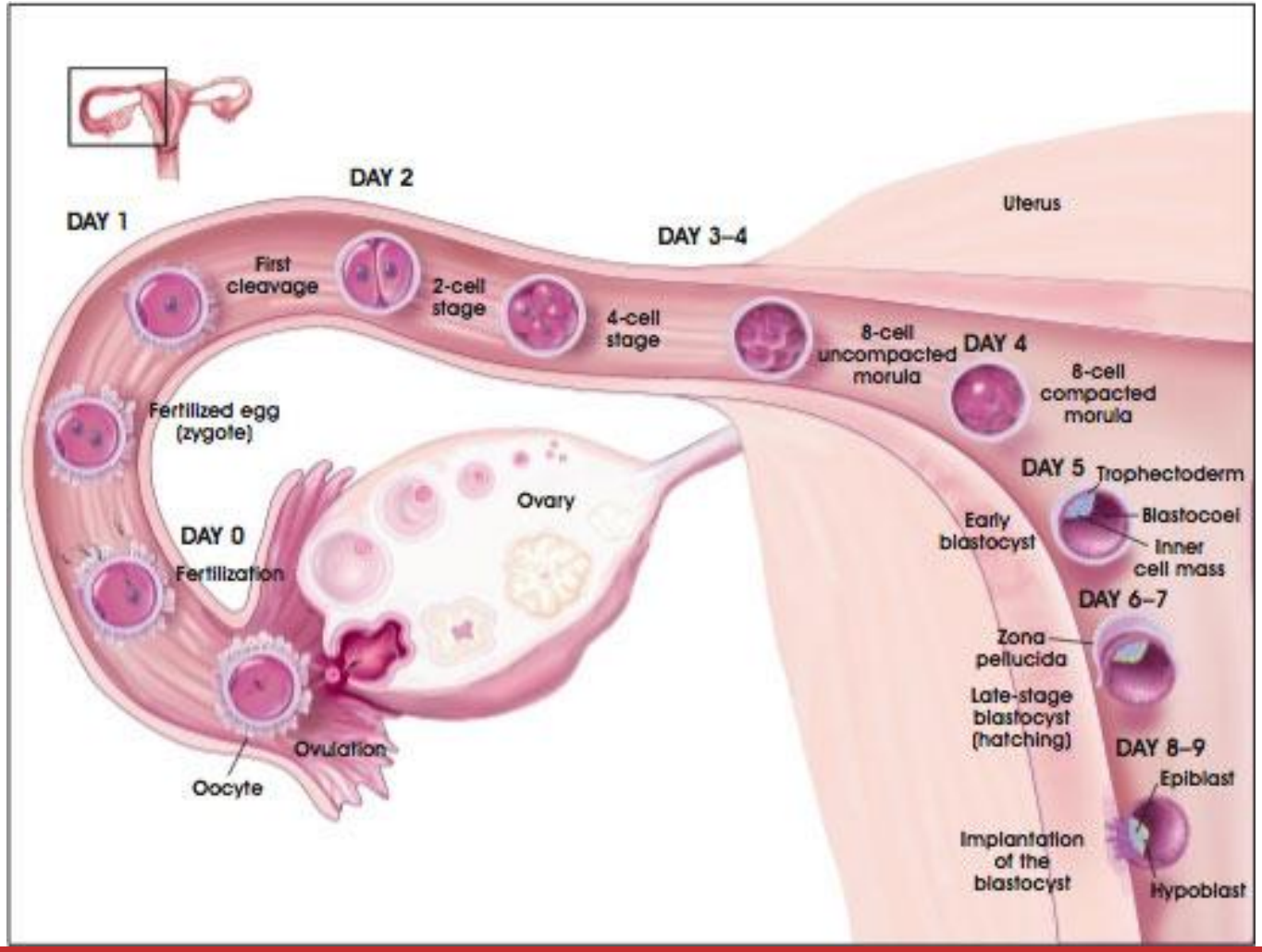
- After ejaculation sperms reach ampulla of fallopian tube within 5-10 min (ut cont)
- Sperm penetrate corona radiata and zona pellucida (hyaluronidase)
- Oocyte divides to form mature ovum (female pronucleus 23 unpaired chr) + 2^{nd} polar body
- Head of sperm swells (male pronucleus 23 unpaired chr)
- Fertilized ovum (zygote) contain 23 paired chr

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

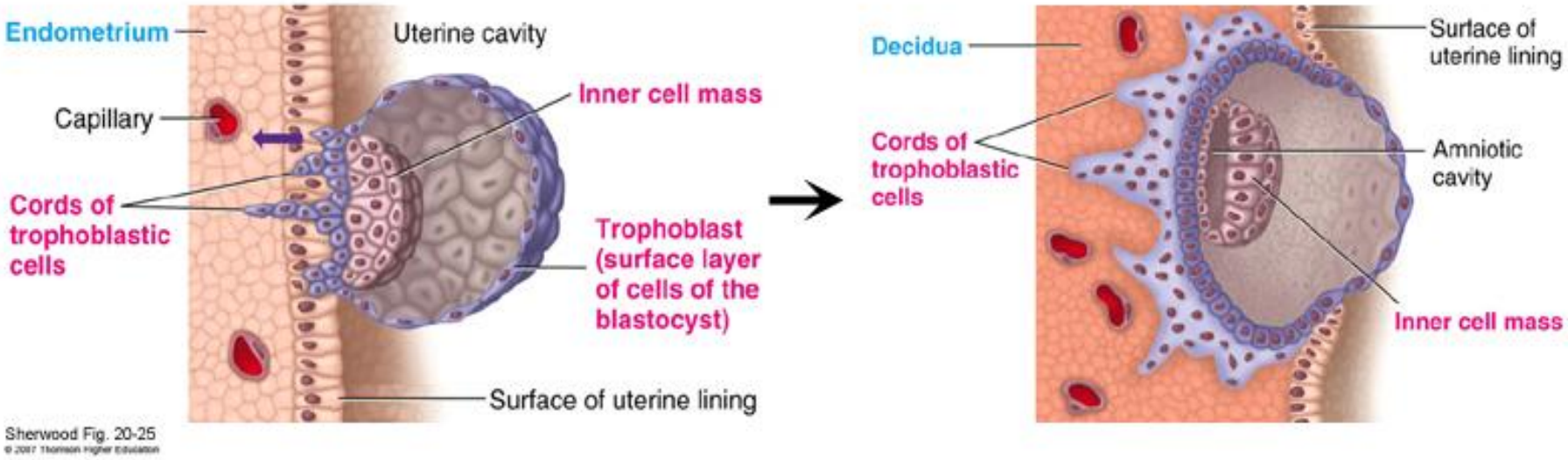
Transport of fertilized ovum



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

Implantation



Sherwood Fig. 20-25

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)

Placenta

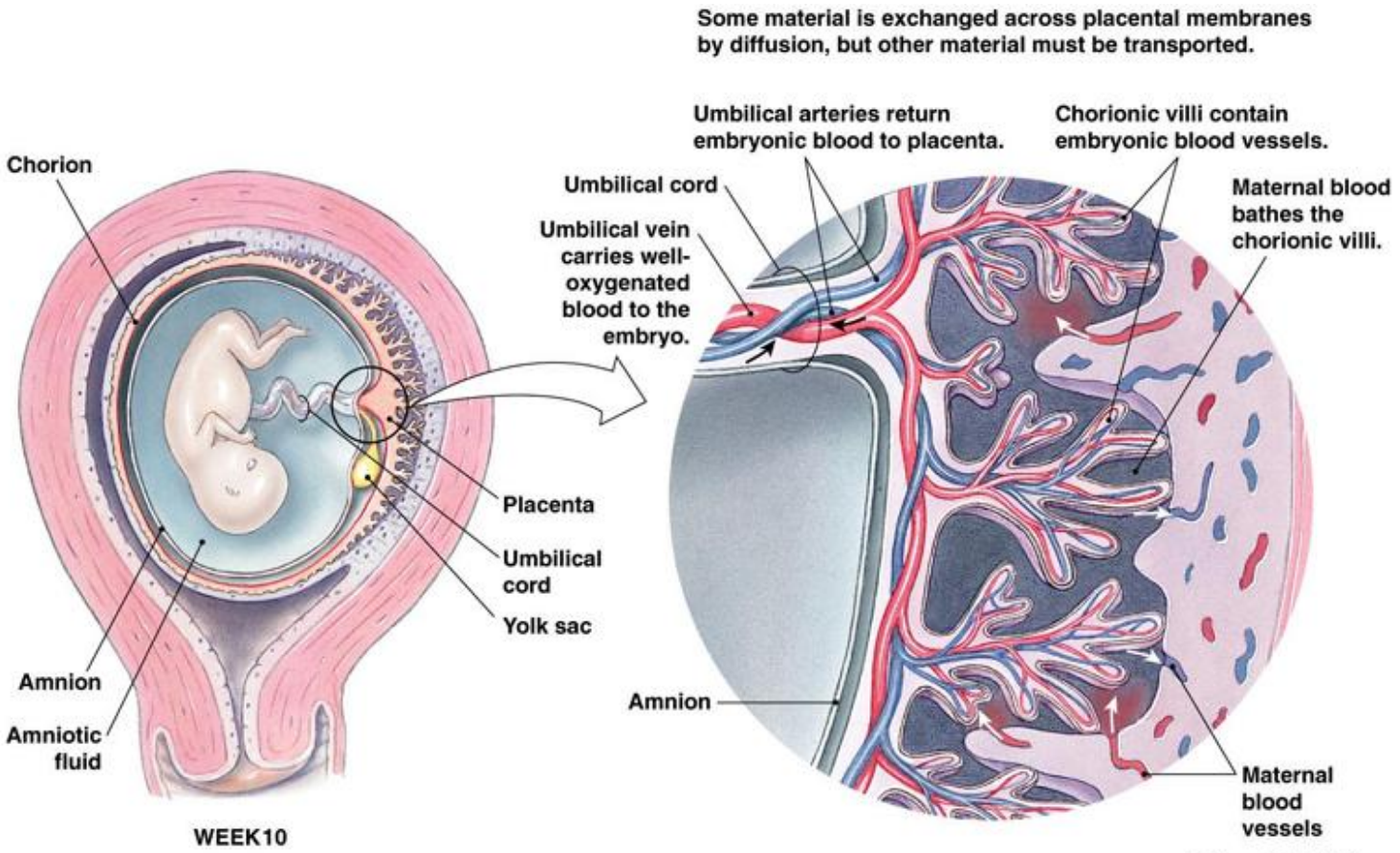


Fig. 26-19

Function of the placenta

- Major function:
  - Respiration
  - Nutrition
  - Excretion
- Endocrine
- Protection

Respiration

- Dissolved O_2 in mother's blood passes to fetal blood by simple diffusion

  PO_2 50 mm Hg (M) - 30 mm Hg (F) =20 mmHg

  - At low PO_2HbF carry 20-50% more O_2 than HbA
  - Fetal Hb conc 50% higher than in mother
  - Double Bohr effect
    - low pH in mother's blood (acidic)
    - High pH in fetal blood (alkaline)
- PCO_2 2-3 mm Hg higher in fetal than maternal blood

Respiration

Nutrition

- Fetus uses mainly glucose for nutrition so the trophoblast cells in placental villi transport glucose by carrier molecules (facilitated diffusion)
- Fatty acids diffuses due to high solubility in cell membrane (more slowly than glucose)
- Ketone bodies, K+, Na+ and Cl- diffuses from maternal to fetal blood

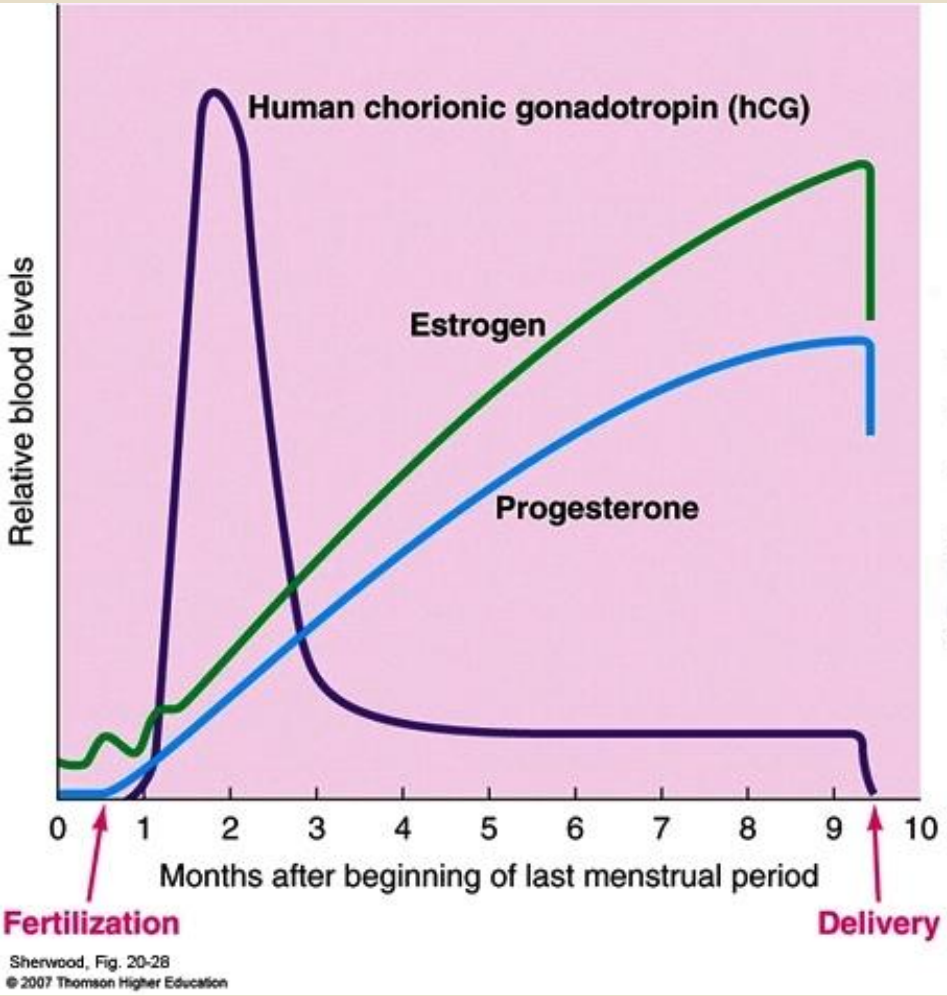
Excretion

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

Endocrine

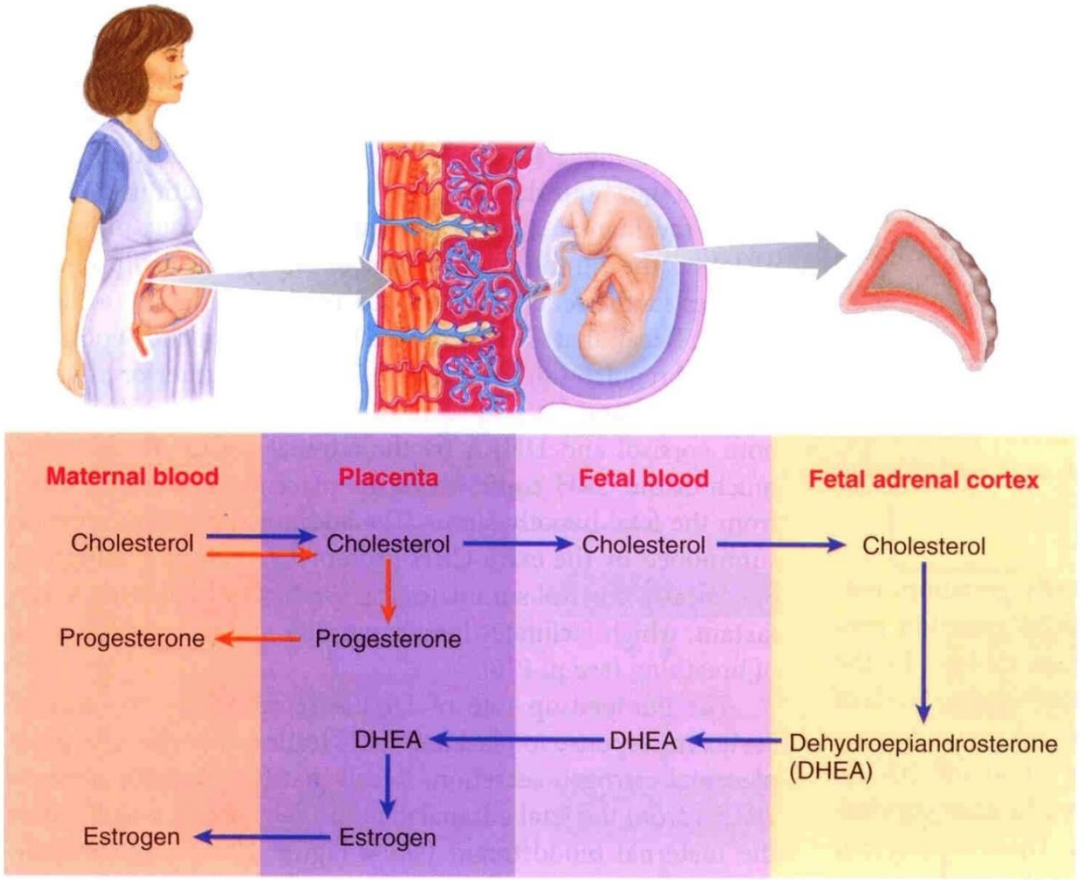
- Human Chorionic Gonadotropin (hCG)
  - Glycoprotein
  - Most important function is to maintain corpus luteum (↑estrogen & progesterone) till 13-17 weeks of gestation
  - Exerts interstitial (Leyding) cell-stimulating effect on testes of the male fetus (growth of male sex organs)

hCG level (pregnancy test)



Endocrine

- Estrogen
  - Steroid hormone
  - Secreted by syncytial trophoblast cells
  - Towards end of pregnancy reaches 30×
  - 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



● **FIGURE 20-31 Secretion of estrogen and progesterone by the placenta.** The placenta secretes increasing quantities of progesterone and estrogen into the maternal blood after the first trimester. The placenta itself can convert cholesterol into progesterone *(orange pathway)* but lacks some of the enzymes necessary to convert cholesterol into estrogen. However, the placenta can convert DHEA derived from cholesterol in the fetal adrenal cortex into estrogen when DHEA reaches the placenta by means of the fetal blood *(blue pathway)*.

Endocrine

- Progsterone
  - 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
  - Development of decidual cells
  - Inhibit the contractility of the uterus

Endocrine

- Human Chorionic Somatotropin
  - Protein hormone
  - Secreted by placenta around 5th gestational week
- Functions in the mother
  - Breast development (hPL)
  - Weak growth hormone ‘s action
  - Inhibit insulin sensitivity =↓ glucose utilization
  - Promote release of fatty acids

Endocrine

- Relaxin
  - Polypeptide
  - Secreted by corpus luteum and placenta
- Functions in the mother
  - Relaxation of symphysis pubis ligament (weak)
  - Softens the cervix at delivery

Physiological adaptation to pregnancy

Changes in maternal endocrine system

- Anterior pituitary gland enlargement (50%)
  - Release of ACTH, TSH and PL 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, hCT)
- 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
- Masculine or acromegalic features
- Weight gain 10-12 kg (last 2 trimesters)
  - Increase appetite
    - Removal of food by fetus
    - Hormonal effect

Changes in metabolism

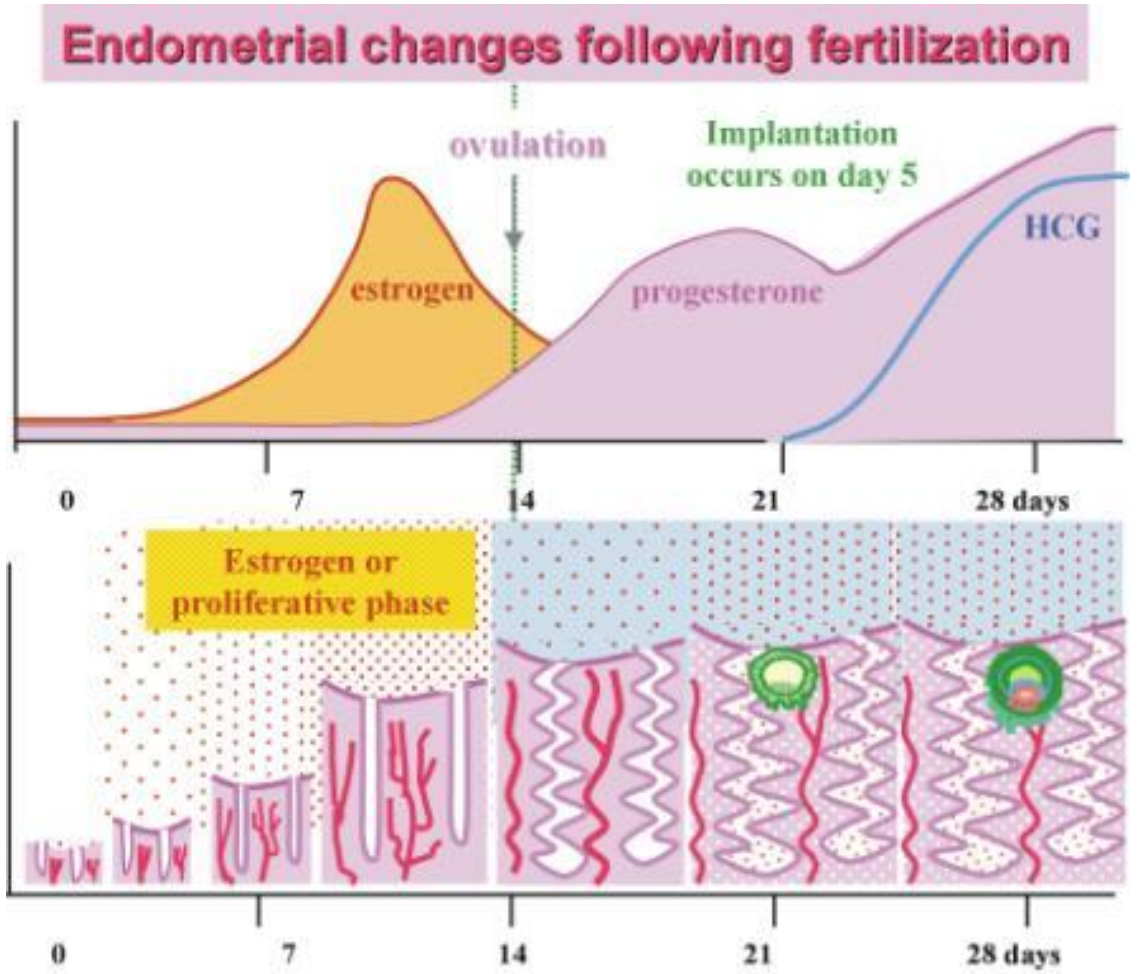
- Increase basal metabolic rate (15%)
- Increase in daily requirements for
  - Iron
  - Phosphates
  - Calcium
  - Vitamins
    - Vitamin D (Ca^{+2} absorption)

Changes in circulatory system

- Increase in COP (30-40%) by 27 weeks
- Increase in blood flow through the placenta
- Increase in maternal blood volume (30%) due to
  - increase aldosterone and estrogen (↑ ECF)
  - Increase activity of the bone marrow (↑ RBCs)

Changes in respiration

- Increase in O_2 consumption (20%)
  - Increase BMR
  - Increase in body size
- Growing uterus presses upwards
- Increase in RR
- Increase in minute ventilation(TV× RR) by 50%
  - Progesterone ↑sensitivity of RC to CO_2


Endometrial changes following fertilization
ovulation
Implantation
occurs on day 5
HCG
estrogen
progesterone
0
7
14
21
28 days
Estrogen or
proliferative phase
0
7
14
21
28 days