

Physiology of pregnancy



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Objectives



Fertilization

Development and function of the placenta

Placenta as an endocrine organ

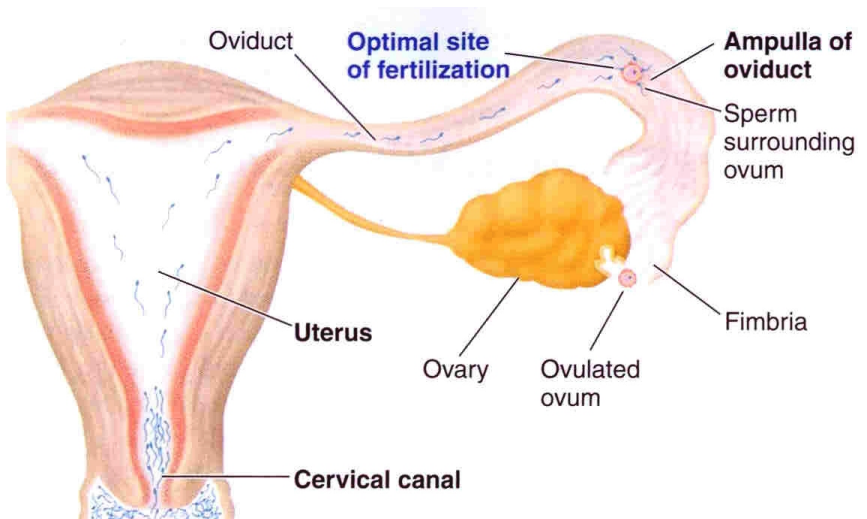
Physiological functions of placental hormones

Maternal adaptation to pregnancy

Fertilization



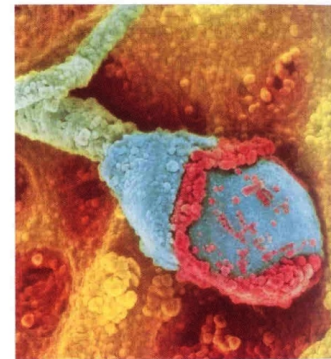
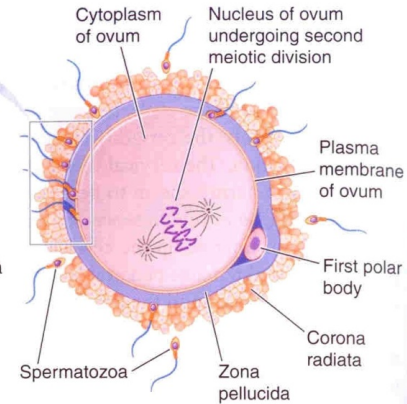
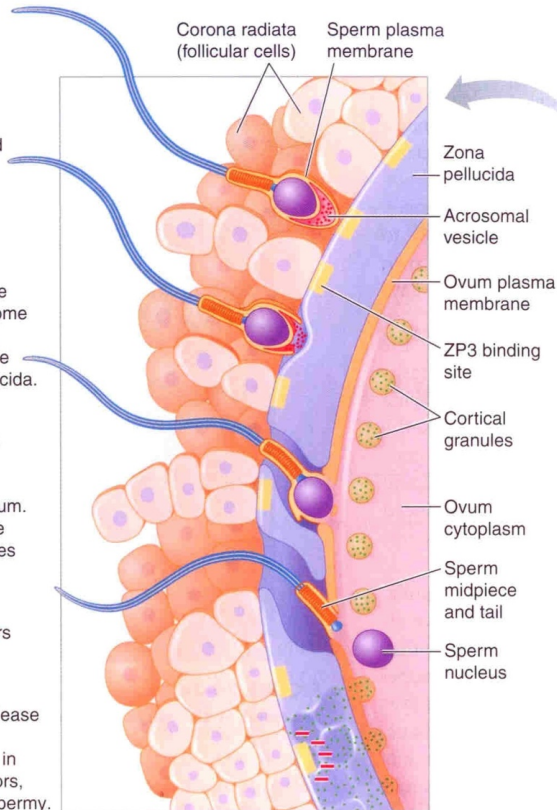
Location	Time of appearance (min after ejaculation)	Percent of ejaculated sperm*
Fertilization site (upper third of oviduct)	30-60	0.001
Uterus	10-20	0.1
Cervical canal	1-3	3



Fertilization

- 1** The fertilizing sperm penetrates the corona radiata via membrane-bound enzymes in the plasma membrane of its head and binds to ZP3 receptors on the zona pellucida.
- 2** Binding of sperm to these receptors triggers the acrosome reaction, in which hydrolytic enzymes in the acrosome are released onto the zona pellucida.
- 3** The acrosomal enzymes digest the zona pellucida, creating a pathway to the plasma membrane of the ovum. When the sperm reaches the ovum, the plasma membranes of the two cells fuse.
- 4** The sperm nucleus enters the ovum cytoplasm.
- 5** The sperm stimulates release of Ca^{2+} stored in cortical granules in the ovum, which in turn, inactivates ZP3 receptors, leading to the block to polyspermy.

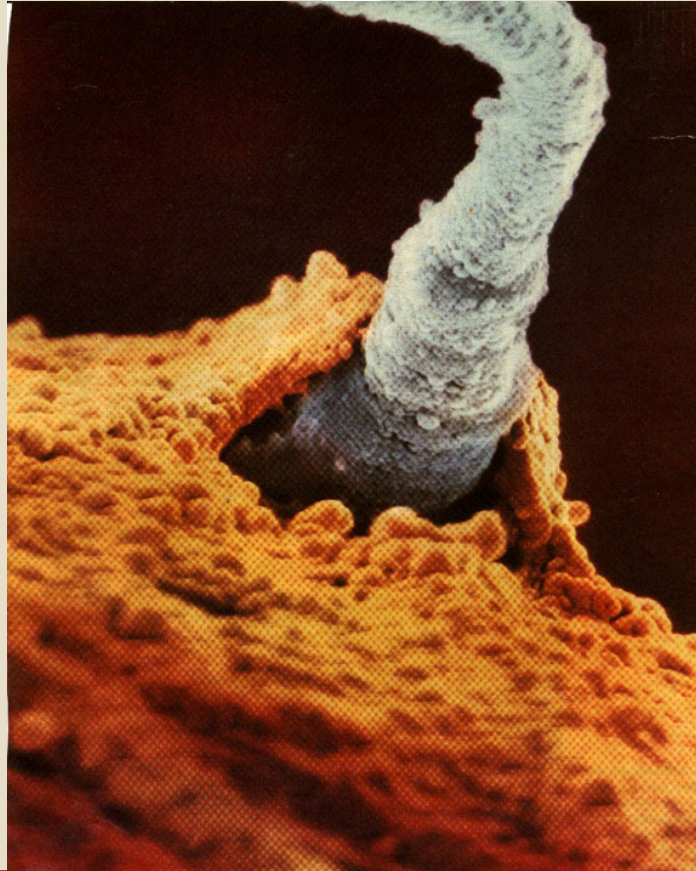
(a) Sperm tunneling through the barriers surrounding an ovum



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

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

Fertilization



Fertilization

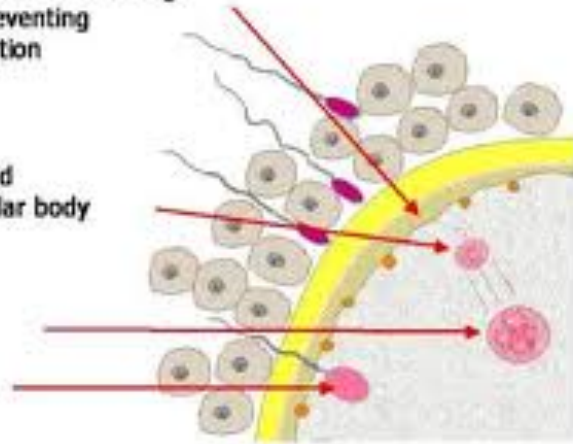


1. release of cortical granules causing the zona reaction, preventing further sperm penetration

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 30-60 min (ut cont)

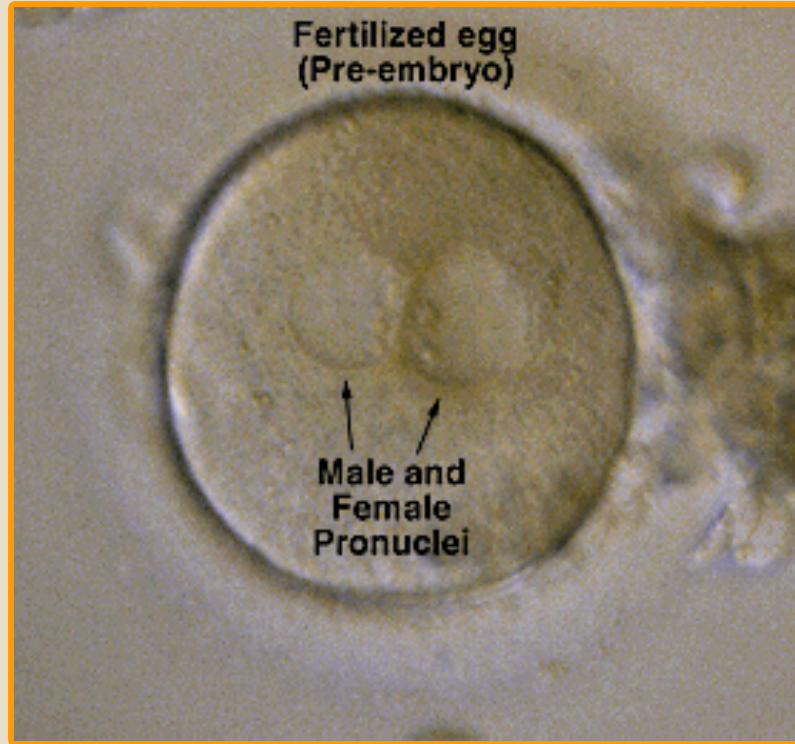
Sperm penetrate corona radiata and zona pellucida (hyaluronidase)

Oocyte divides to form mature ovum (female pronucleus 23 unpaired chr) + 2nd polar body

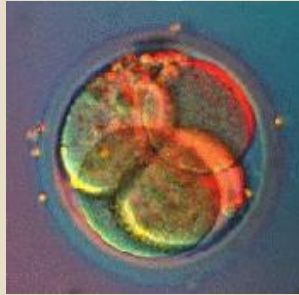
Head of sperm swells (male pronucleus 23 unpaired chr)

Fertilized ovum (zygote) contain 23 paired chr

Zygote



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,

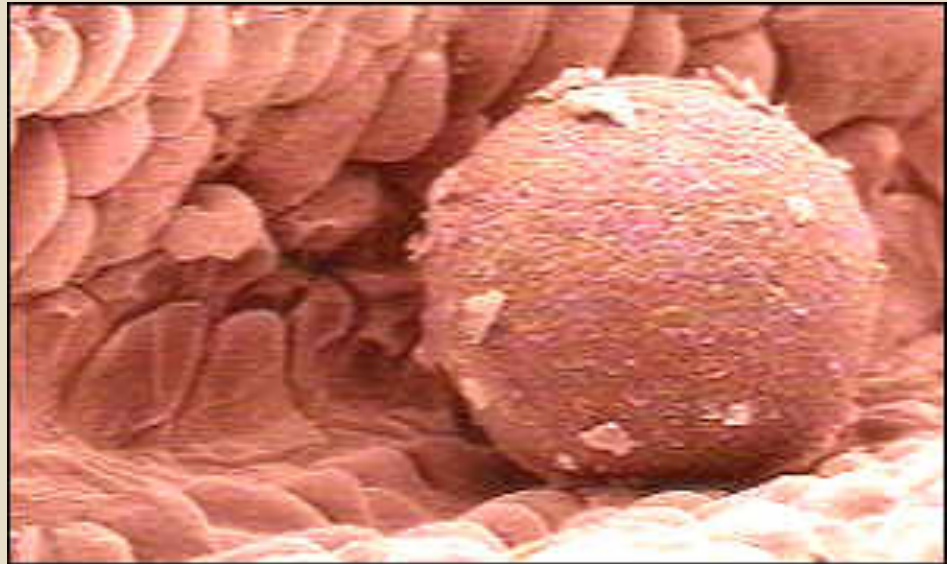
? each cell is called a blastomere and is totipotent

Divisions continue rapidly until the 32 cell stage

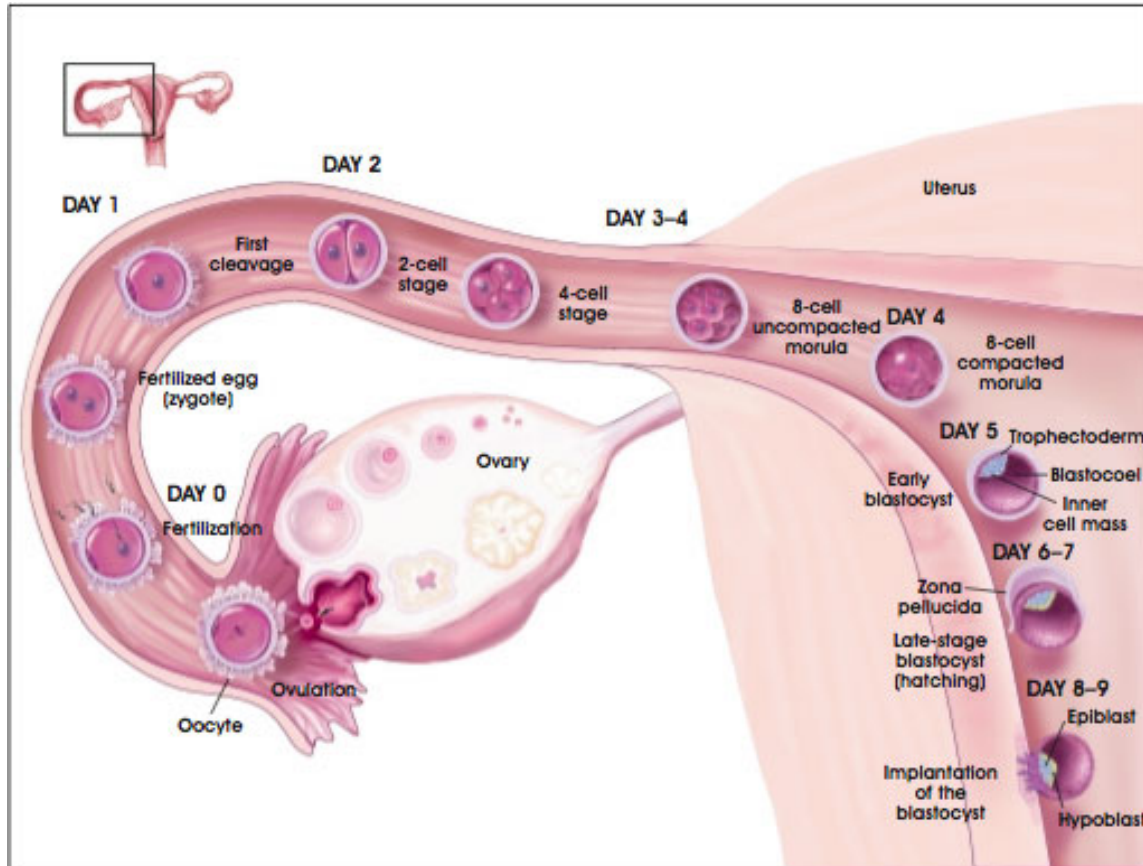
Traveling



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



Transport of fertilized ovum



Transport of fertilized ovum



After fertilization 3-5 days till zygote reach uterine cavity

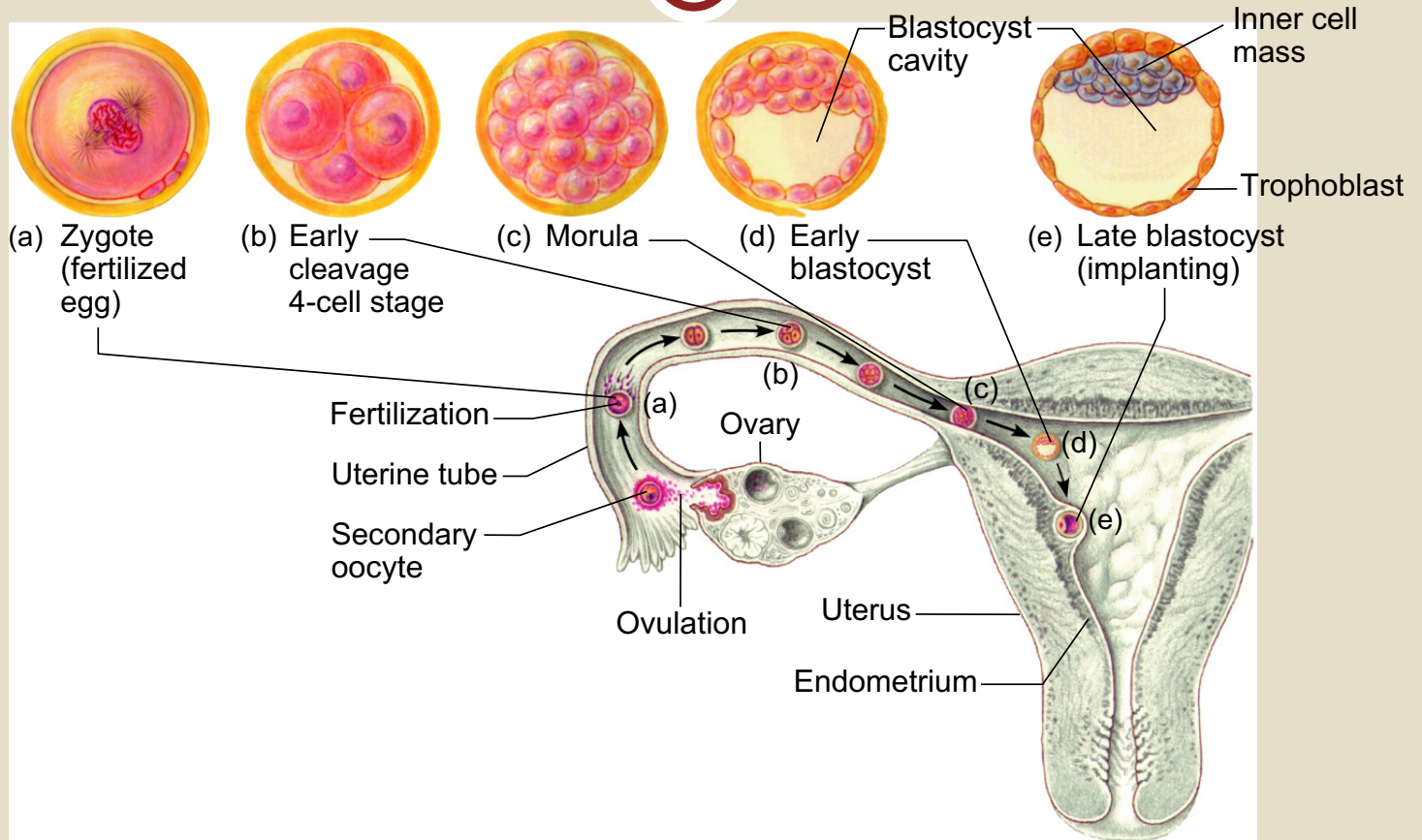
Transport: fluid current + action of cilia + weak contractions of the fallopian tube

Isthmus (last 2cm) relaxes under effect of progesterone

Delayed transport allows cell division

Blastocyst (100 cells) enters the uterus

Cleavage



Cleavage

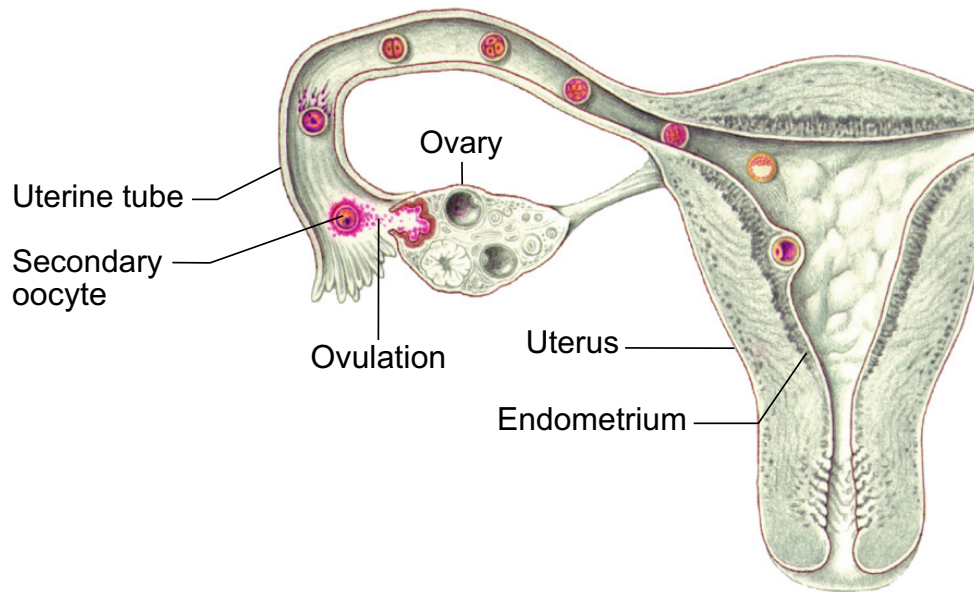
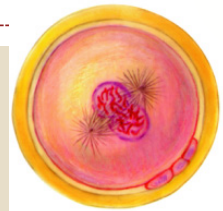


Figure 16.15, step 1

Cleavage



(a) Zygote
(fertilized
egg)

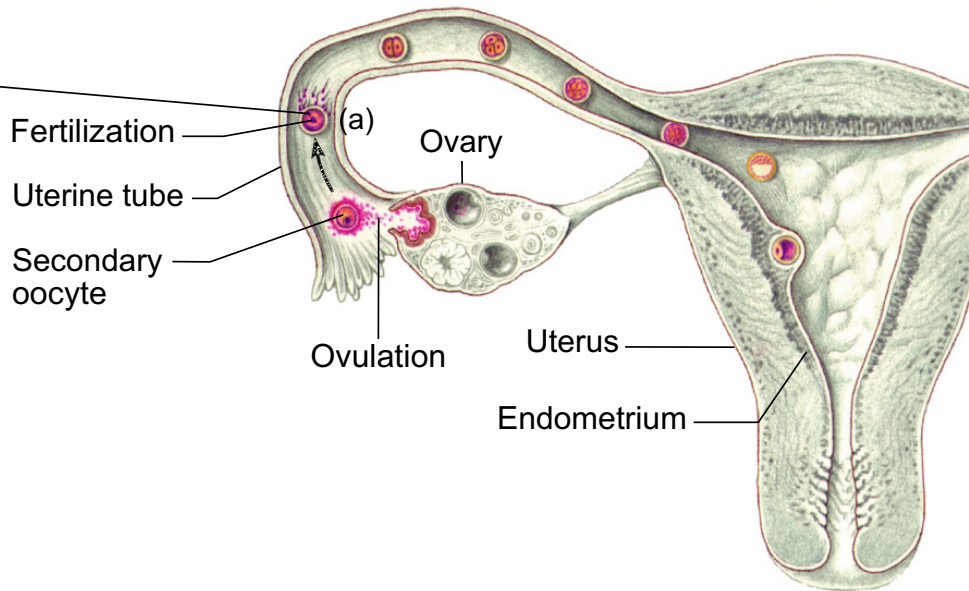


Figure 16.15, step 2

Cleavage

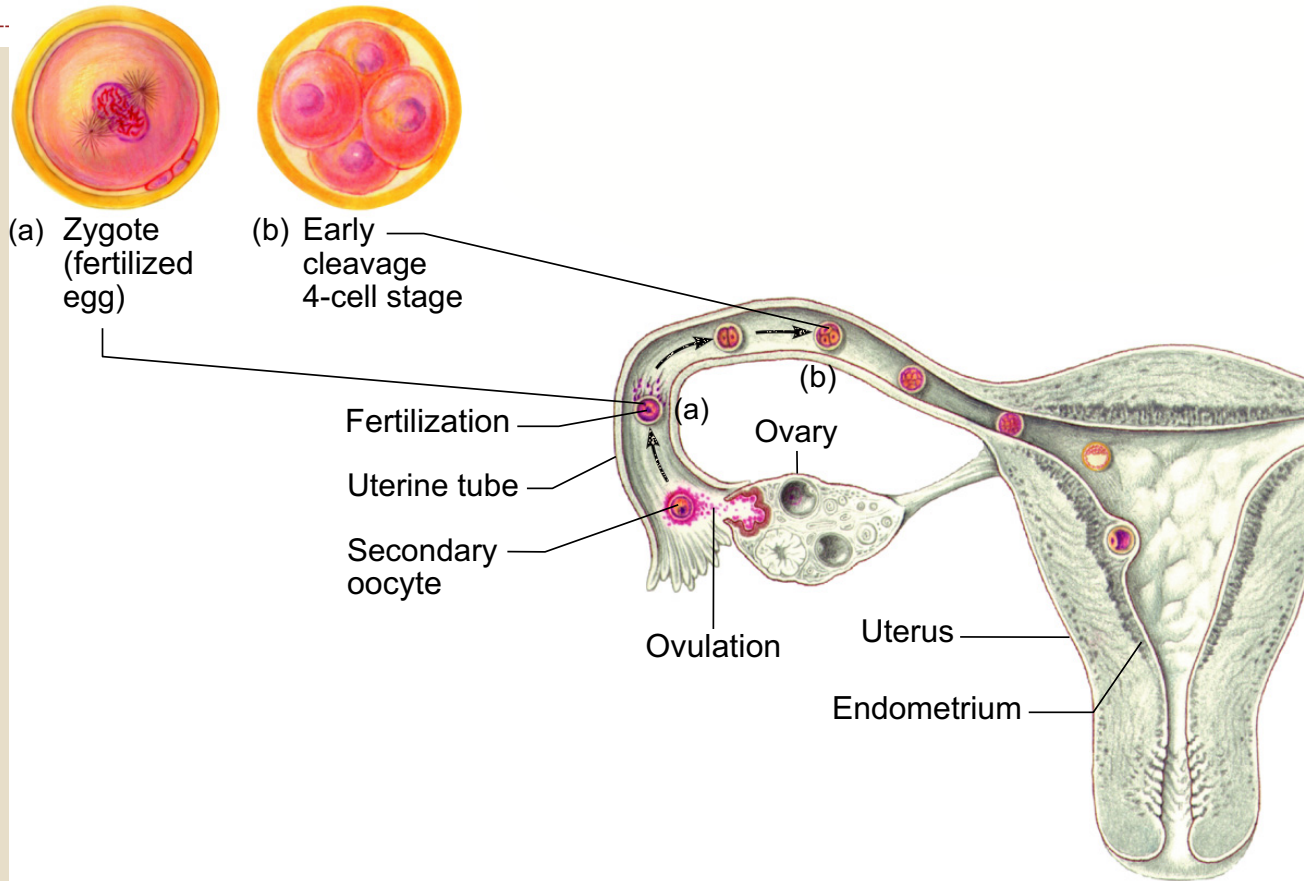


Figure 16.15, step 3

Cleavage

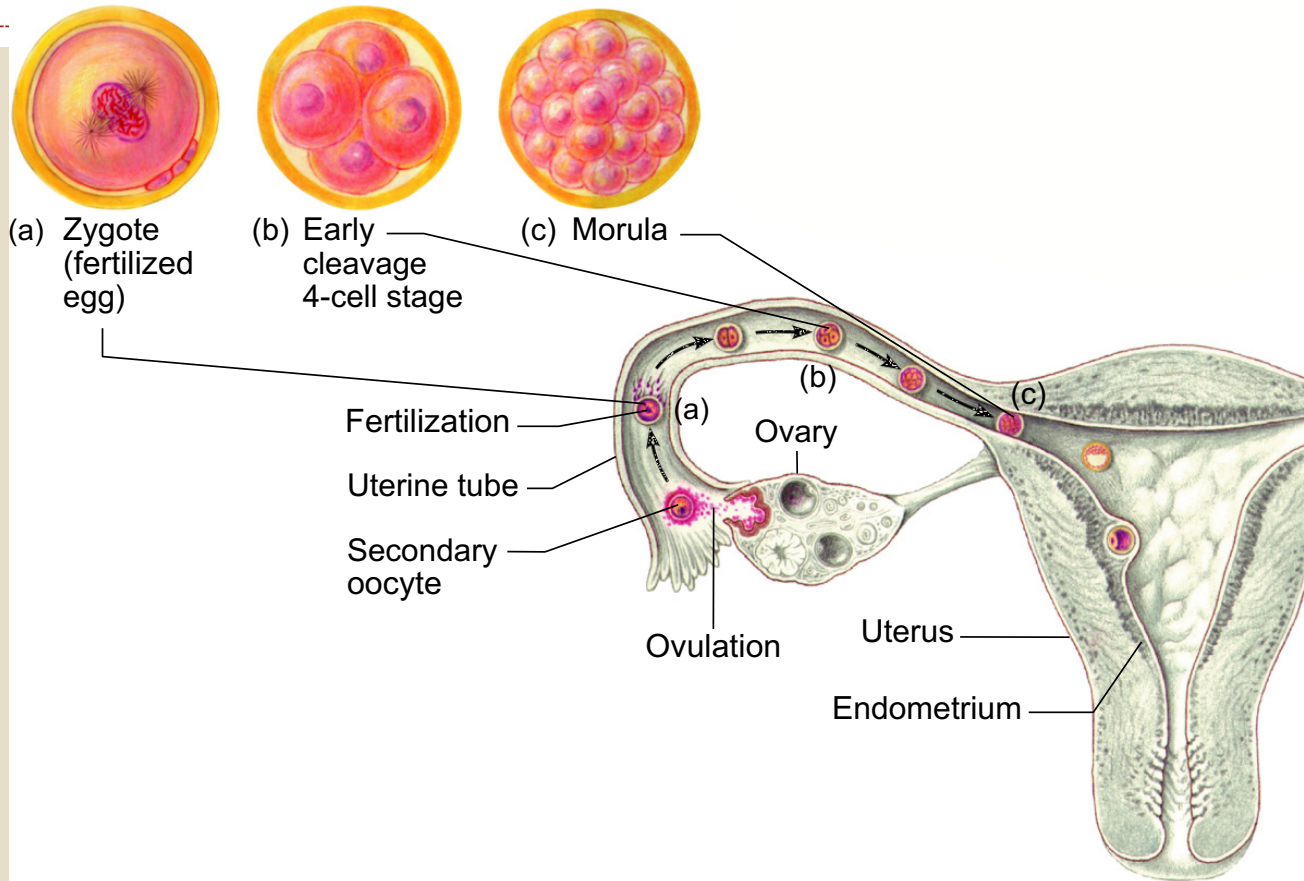


Figure 16.15, step 4

Cleavage

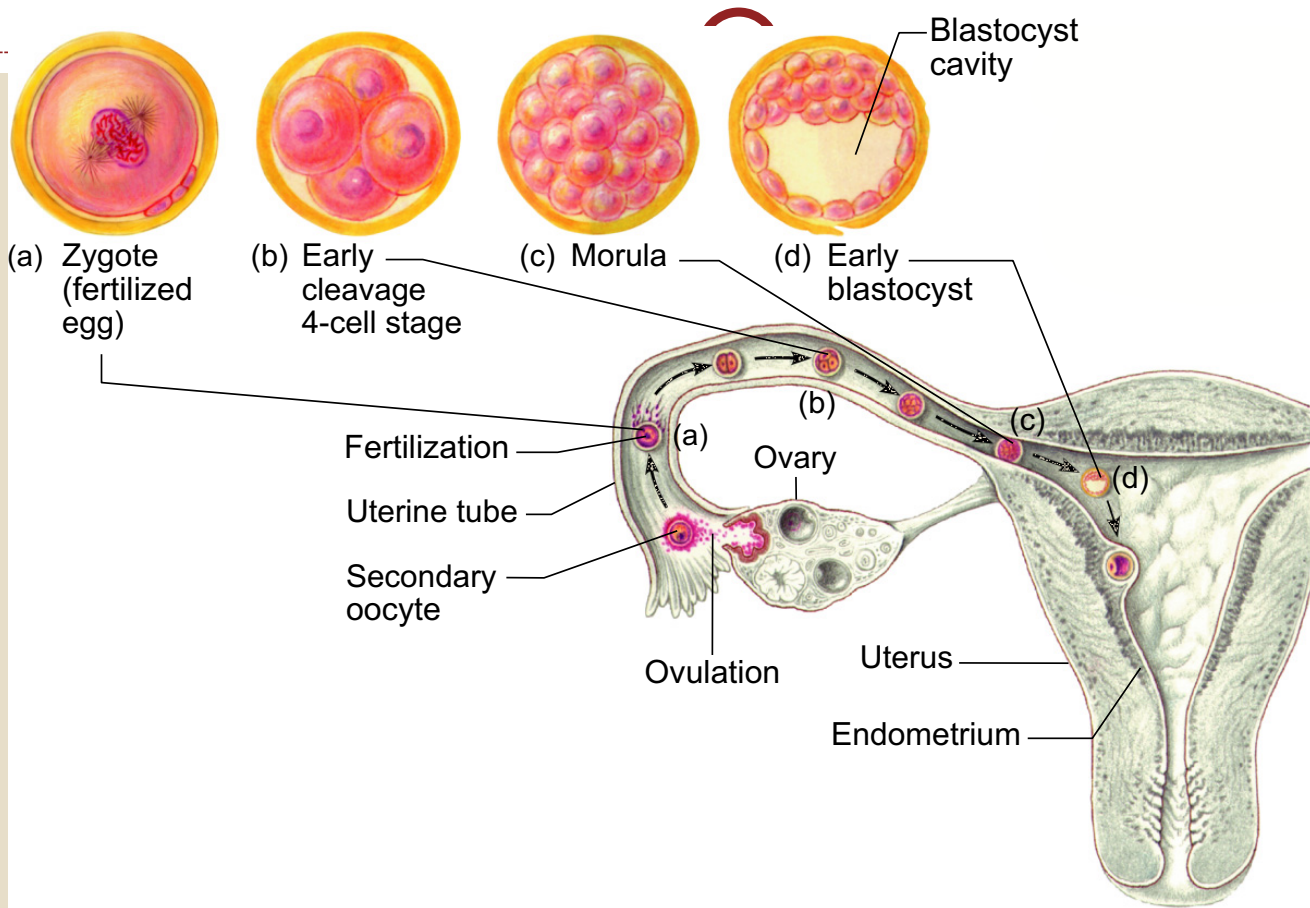
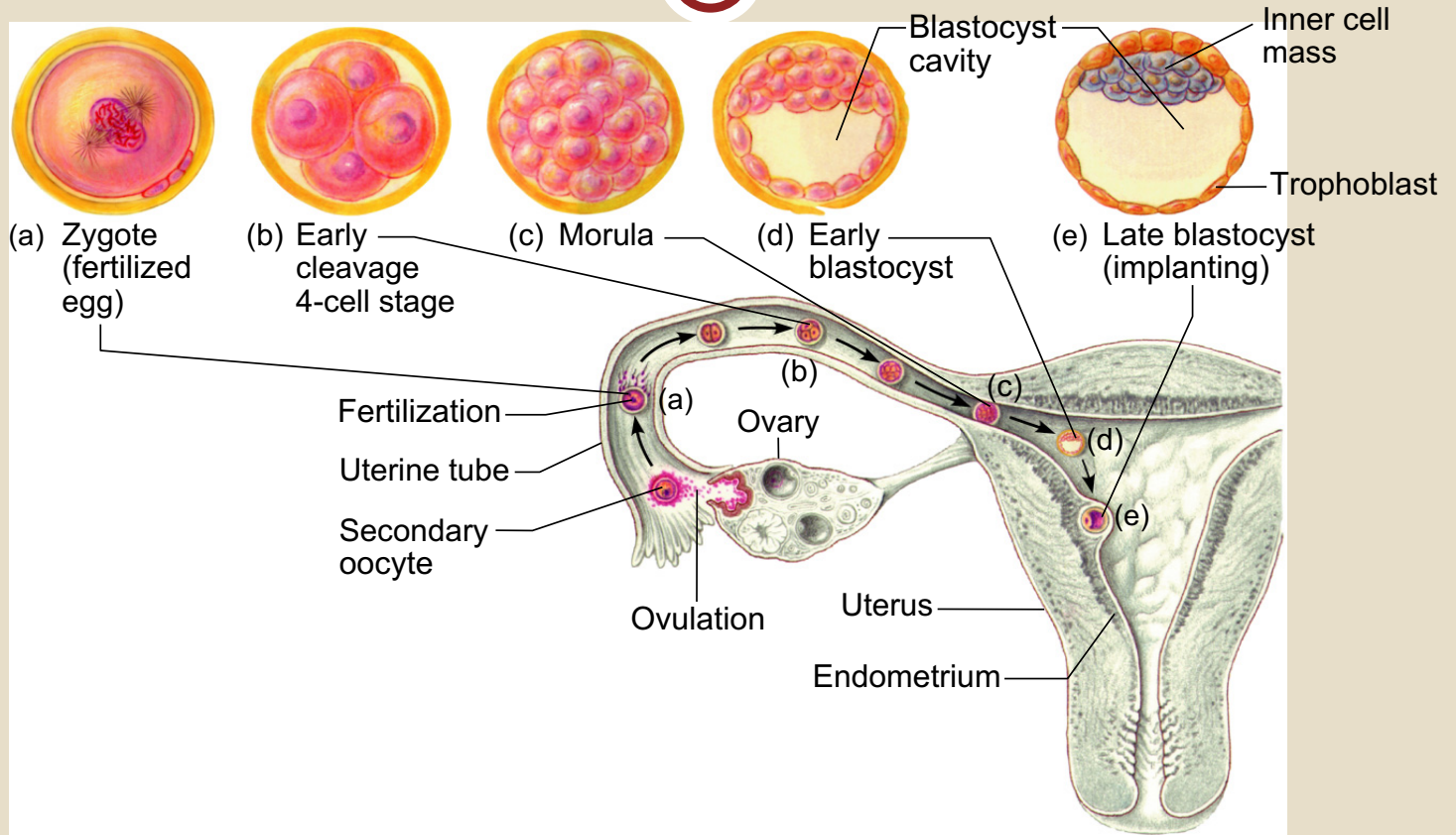
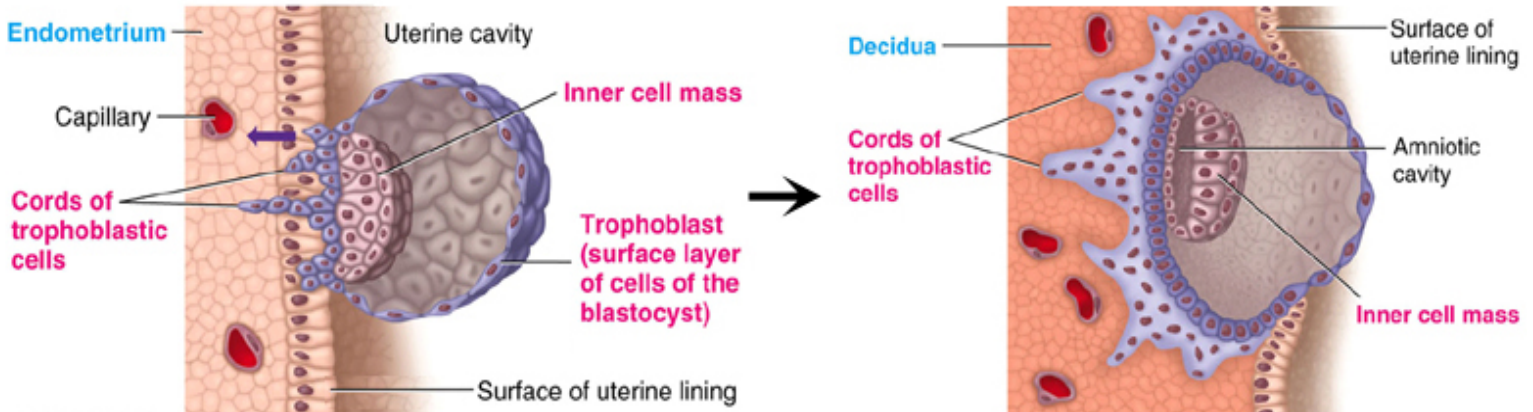


Figure 16.15, step 5

Cleavage



Implantation



Sherwood Fig. 20-25
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مك تبن أ هلل او)

ةفطنل اس ارغن اةي لمع تنج ال اء النع يمسي
 ةمورال اس اب فرغت ي تل او ةمسقن مل اء اش مال ا
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Placenta

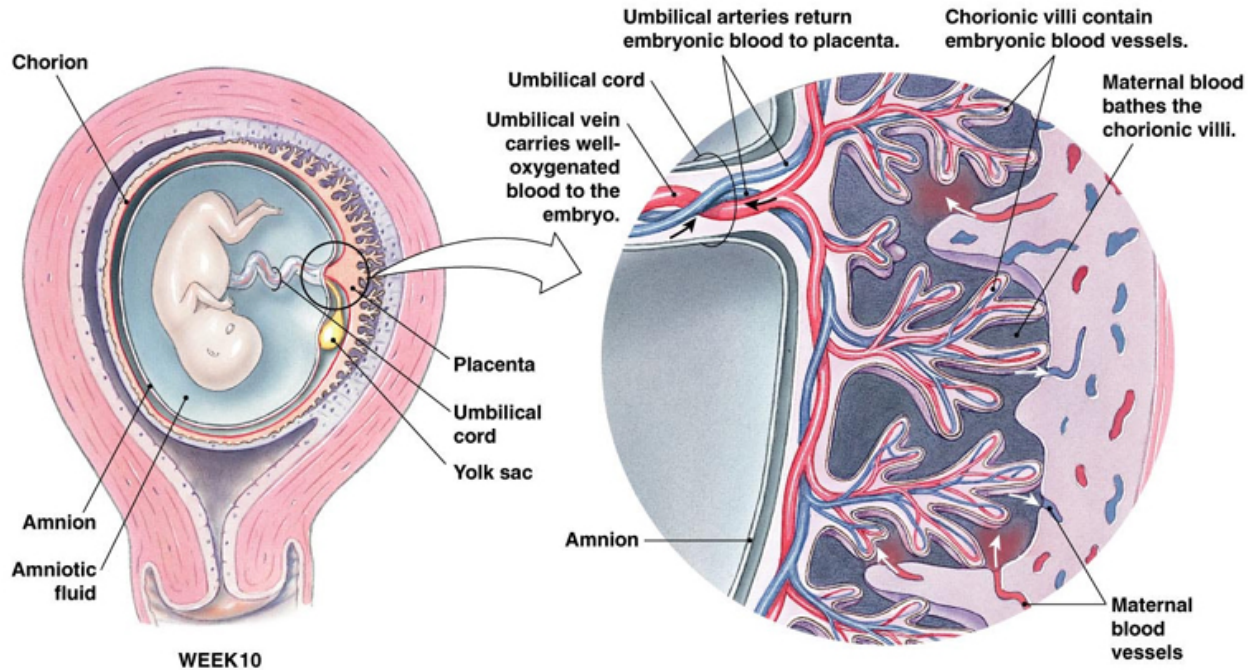


Trophoblastic cords from blastocyst
Blood capillaries grow in the cords
21 days after fertilization blood start to be pumped
by fetal heart into the capillaries
Maternal blood sinuses develop around the
trophoblastic cords
More and more trophoblast projections develop (
placental villi)

Placenta



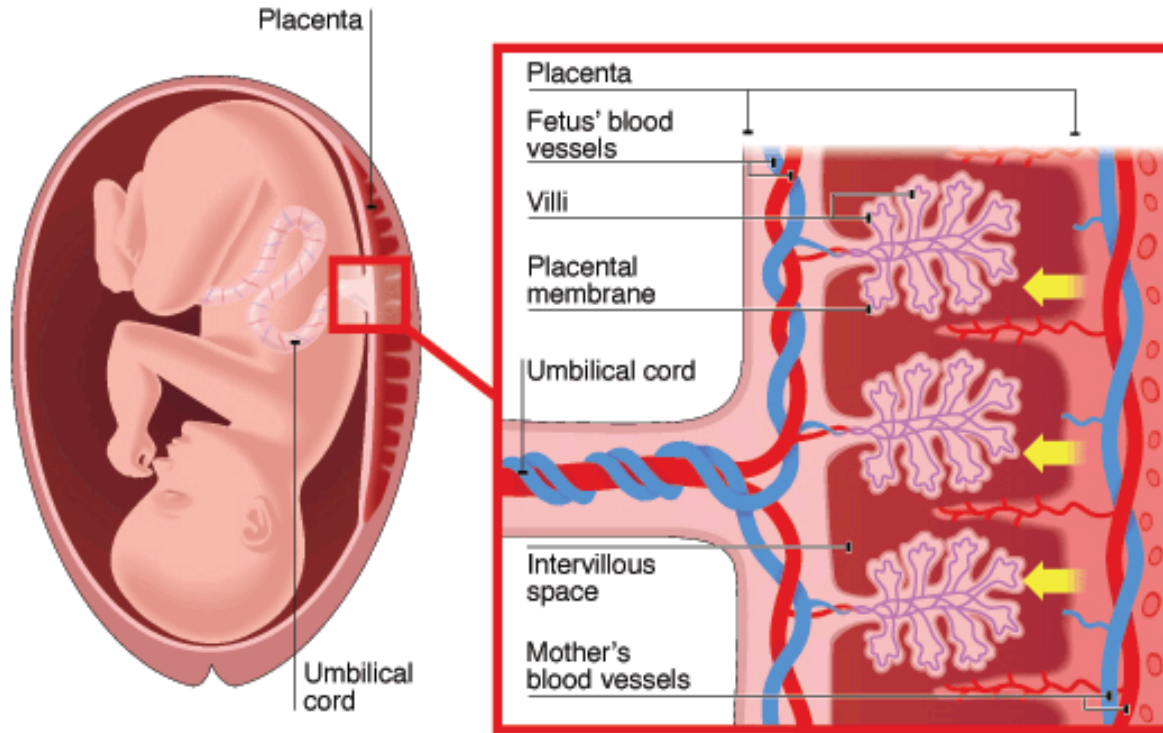
Some material is exchanged across placental membranes by diffusion, but other material must be transported.



WEEK 10

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Fig. 26-19



Function of the placenta



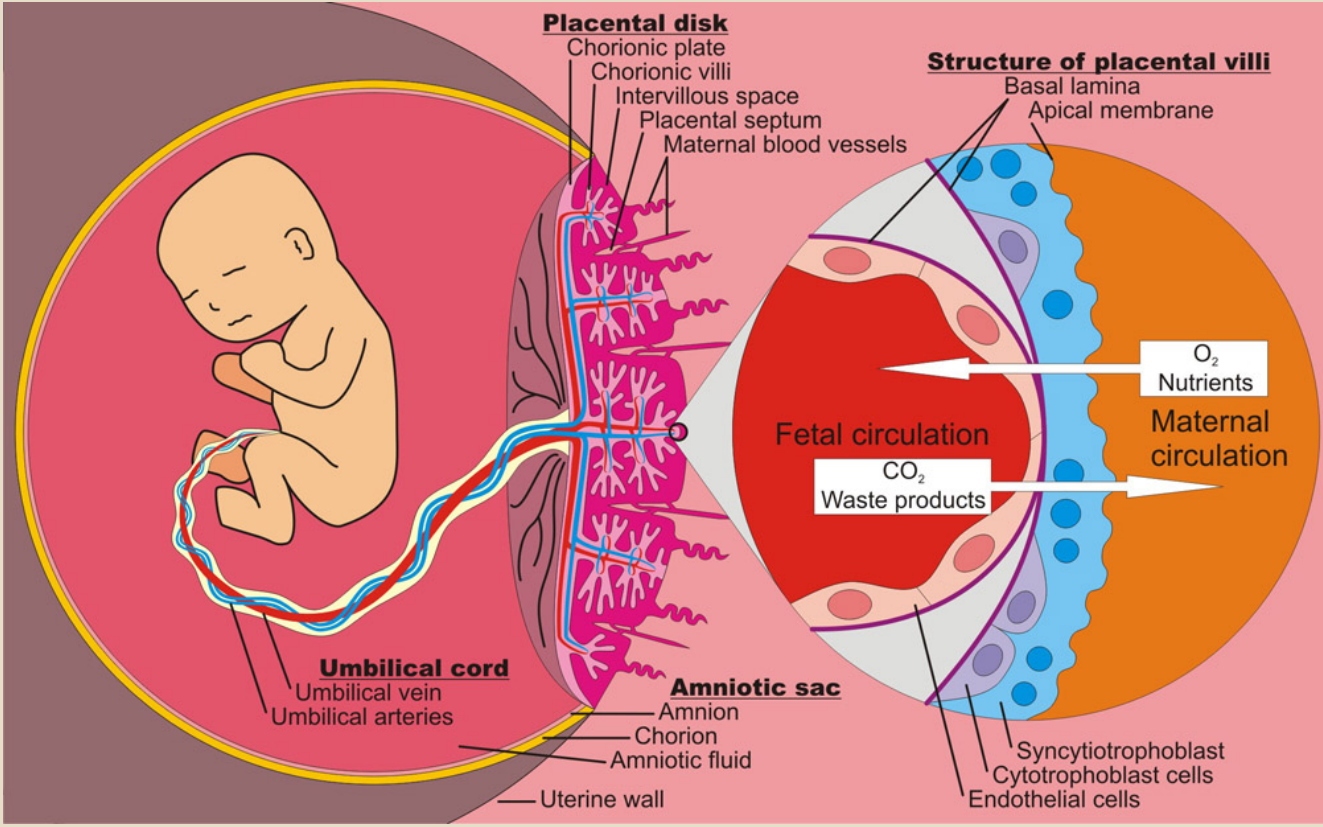
Major function:

- ? Respiration
- ? Nutrition
- ? Excretion

Endocrine

Protection

Respiration



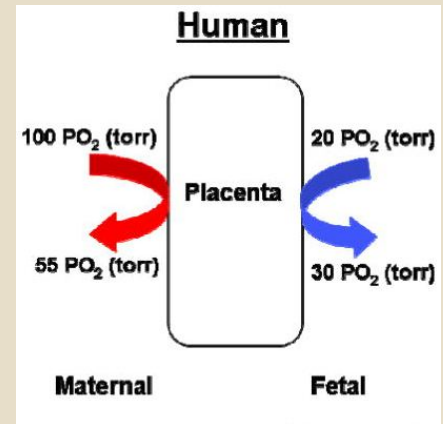
Respiration



PCO₂ 2-3 mm Hg higher in fetal than maternal blood
Dissolved O₂ in mother's blood passes to fetal blood
by simple diffusion

PO₂ 50 mm Hg (M) - 30 mm Hg (F) = 20 mmHg

- At low PO₂ HbF carry 20-50% more O₂ than HbA (HbF has a higher oxygen carrying capacity than HbA)
- HbF conc 50% higher than HbA in mother



Respiration

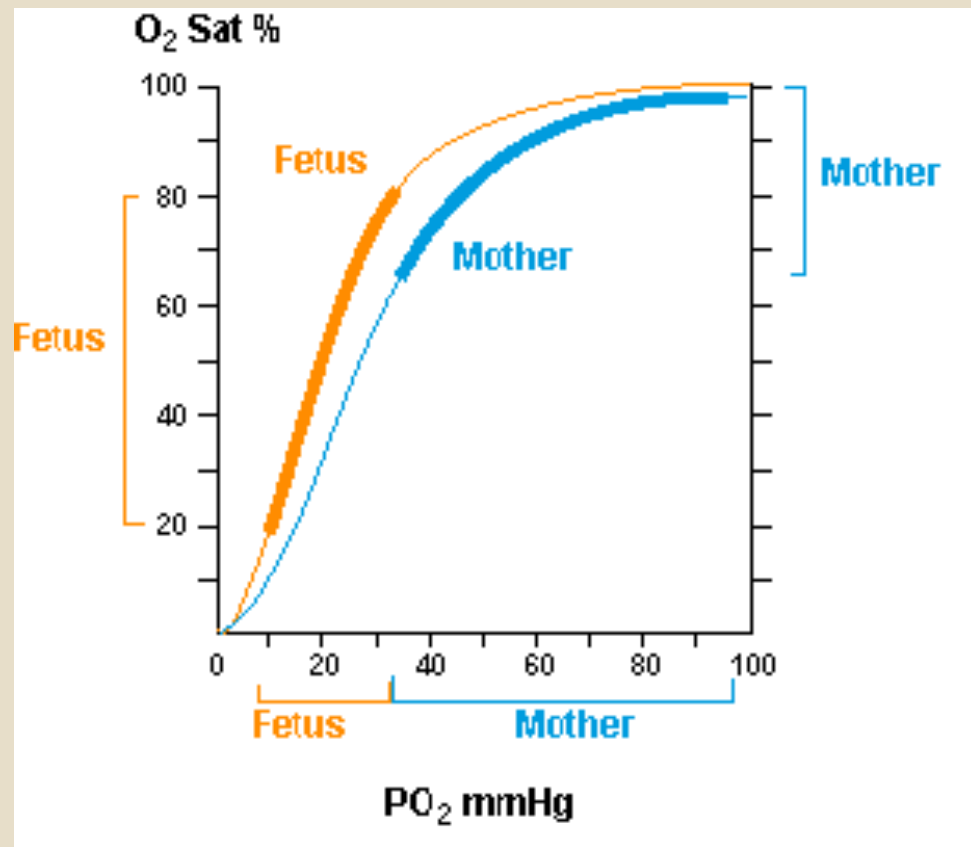


- ? Double Bohr effect
 - ? Low pH in mother's blood (acidic)
 - ? High pH in fetal blood (alkaline)

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

The maternal blood gains CO_2 , 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.

Respiration



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

Excretion



Excretory products of the fetus diffuse through placental membrane to maternal blood to be excreted with waste products of the mother

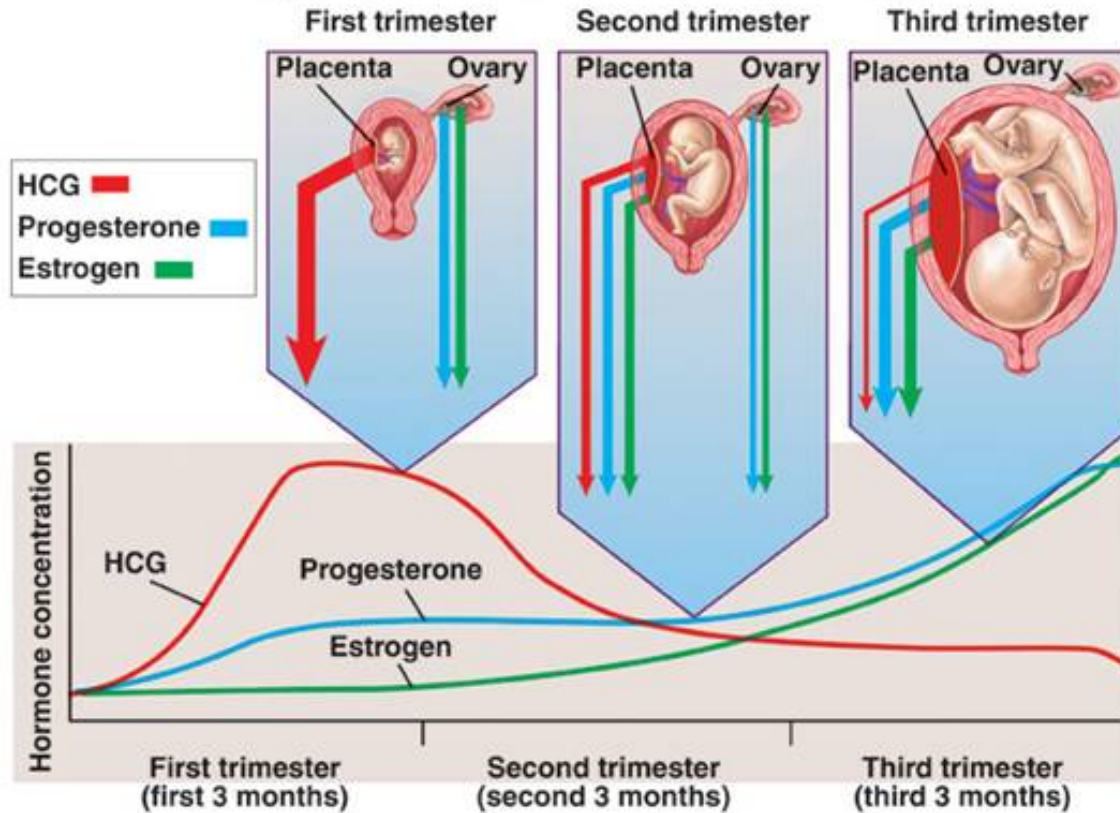
☐ Urea, uric acid and creatinine

Higher conc. Of excretory products in fetal blood insures continuous diffusion of these substances to the maternal blood

Endocrine



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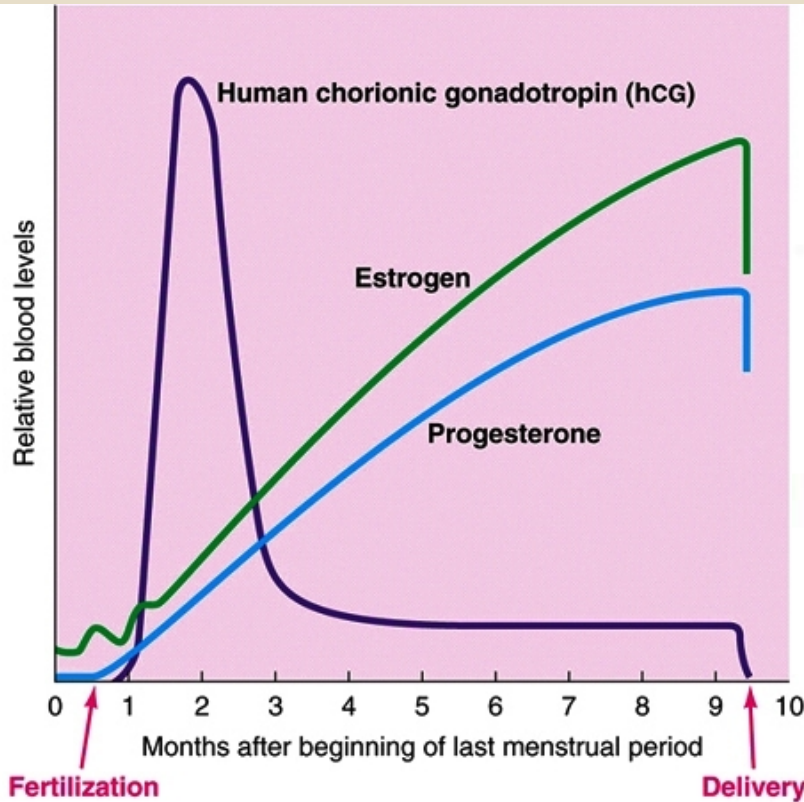
Endocrine



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)



Sherwood, Fig. 20-28
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"Well... I think we should run a pregnancy test. Just to make sure!"

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
- ? Activation of the uterus (gap junctions)

Endocrine

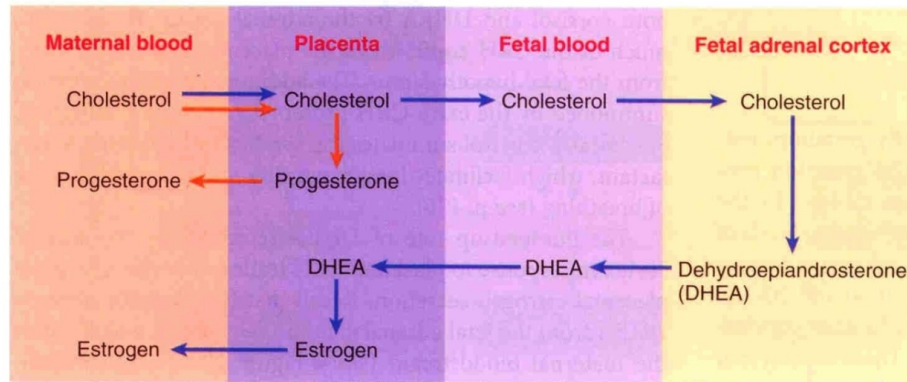
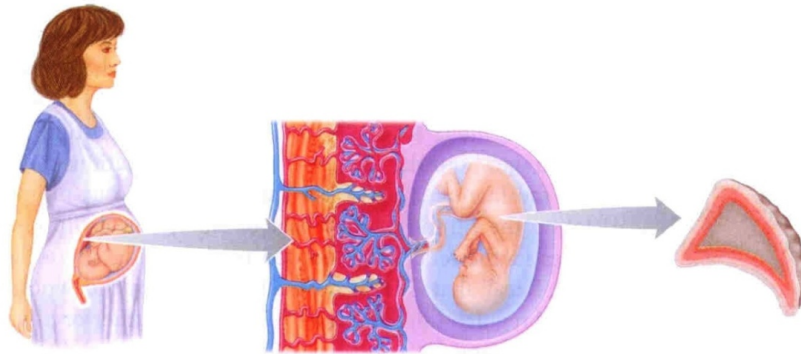


Progesterone

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



KEY

- Orange arrow: Pathway for placental synthesis of progesterone
- Blue arrow: Pathway for placental synthesis of estrogen

● **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



Human Chorionic Somatomamotropin

- ? 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 pubic 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)

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 O₂ consumption (20%)

- ? Increase BMR
- ? Increase in body size

Growing uterus presses upwards (restriction)

Increase in RR

Increase in minute ventilation($TV \times RR$) by 50%

- ? Progesterone \uparrow sensitivity of RC to CO₂



أفعل الله
بمحمد
والآله
والصالحين
الفضل
والجود
والكرام
والعظيم

