REBRODUCTIVE BLOCK

Physiology Team

LECTURE 6

PHYSIOLOGY OF PREGNANCY

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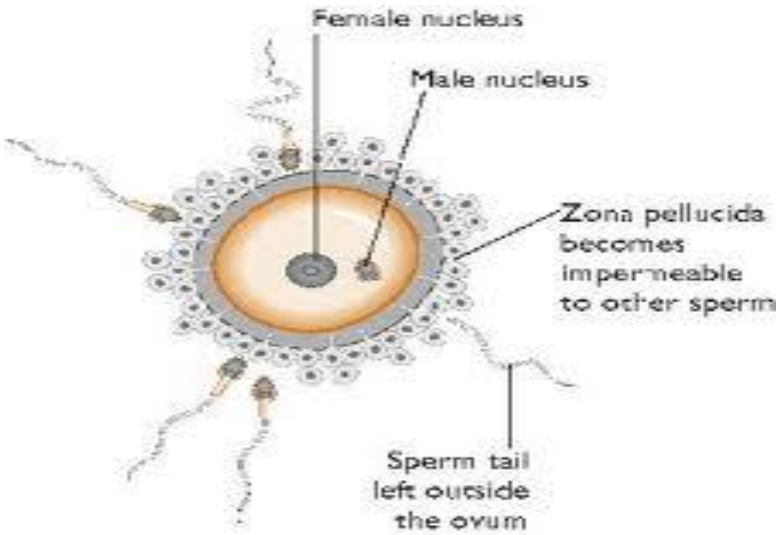
BELIEVE YOU CAN & YOU'RE HALFWAY THERE !
THEODORE ROOSEVELT

By the end of this lecture, you should be able to:

- ✓ Describe **fertilization**
- ✓ Recognize the development and the function of the **placenta**
- ✓ Recognize the placenta as an endocrine organ
- ✓ Describe the physiological functions of placental hormones
- ✓ **Understand the maternal adaptation to pregnancy**



MIND MAP

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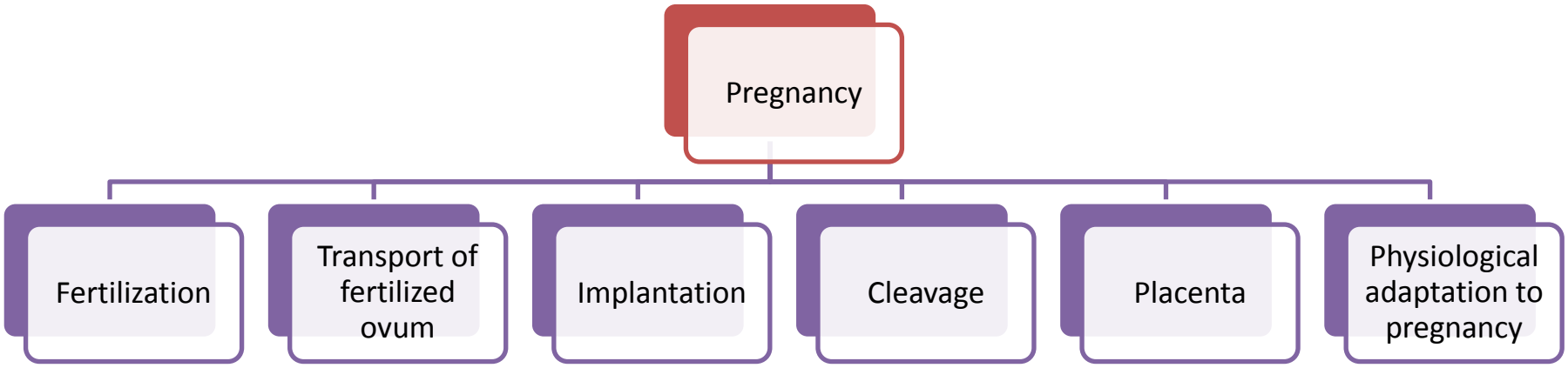

Fertilization

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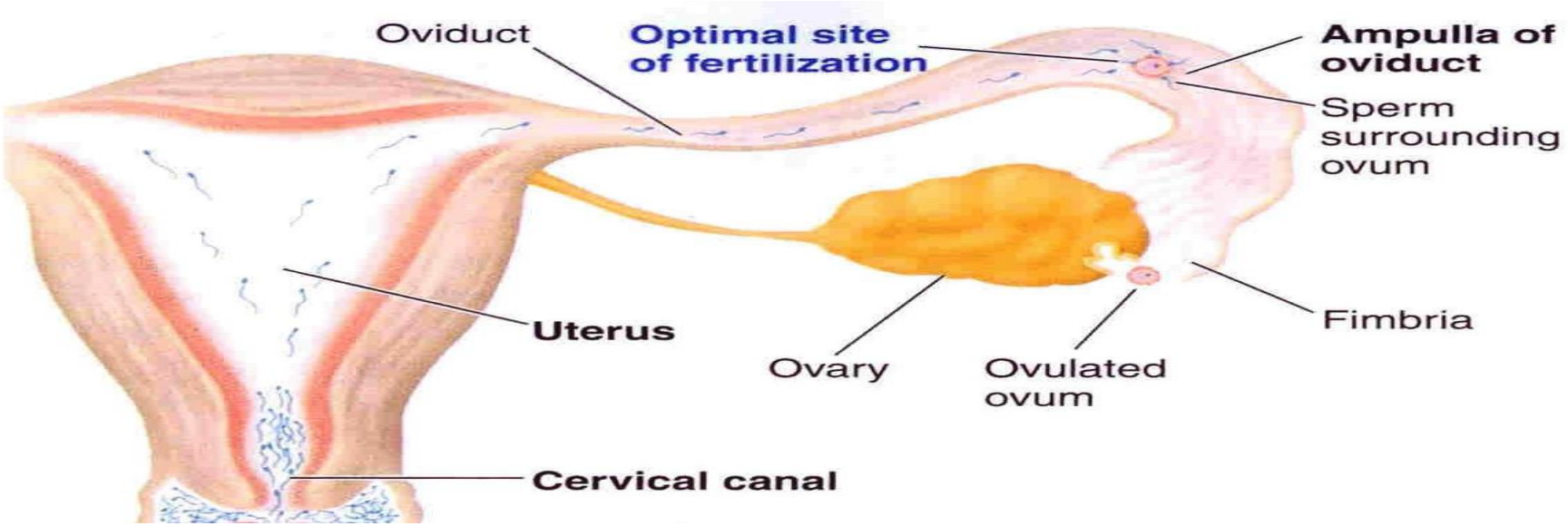
Location	Time of appearance (min after ejaculation)	Percent of ejaculated sperm
Cervical canal	1-3	3
Uterus	10-20	0.1
Upper third of oviduct (Fertilization site)	30-60	0.001



Fertilization

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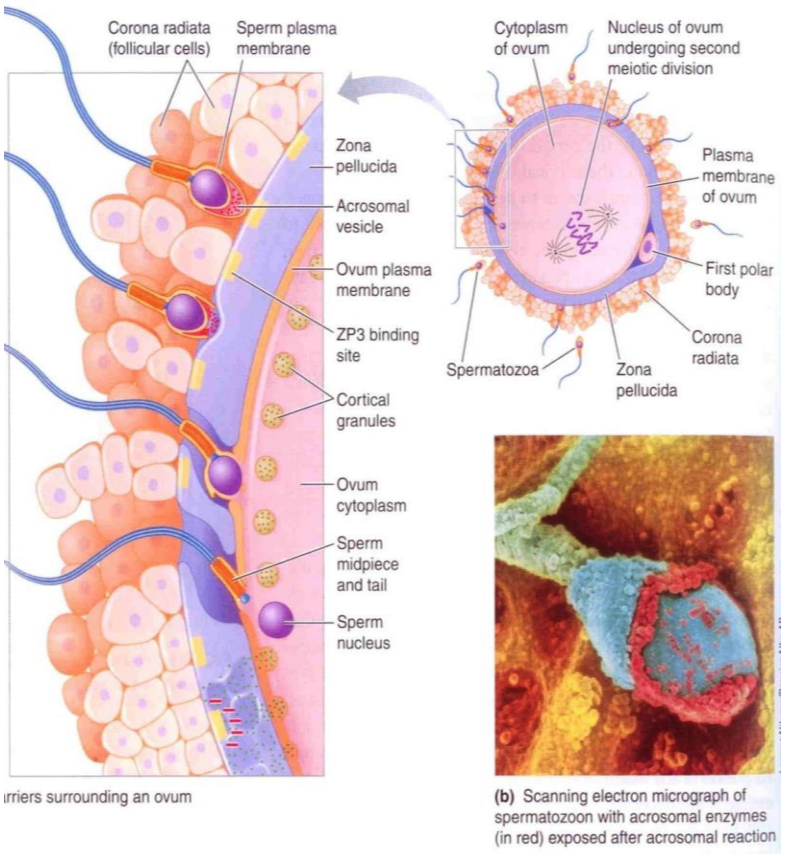
1	• The fertilizing sperm penetrates the corona radiata via membrane-bound enzyme in the plasma membrane of its head and binds to **ZP3 receptors** on the zona pellucida.
2	• Binding of sperm to these receptors triggers the acrosome reaction, in which **Hydrolytic enzymes** in the acrosome are released 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.** • (It takes **one hour** for the sperm to reach the ovum)
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**.



irriers surrounding an ovum

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

- **After ejaculation,** sperms reach **ampulla** of fallopian tube within 30-60 min
- Sperm penetrates corona radiata and zona pellucida (hyaluronidase).
- Oocyte divides to form **mature ovum** (female pronucleus 23 unpaired chromosome)+ 2nd polar body
- Head of sperm swells (male pronucleus 23 unpaired chromosome)
- Fertilized ovum (zygote) contain 23 paired chromosome (46 unpaired)

Cleavage &Transport of fertilized ovum

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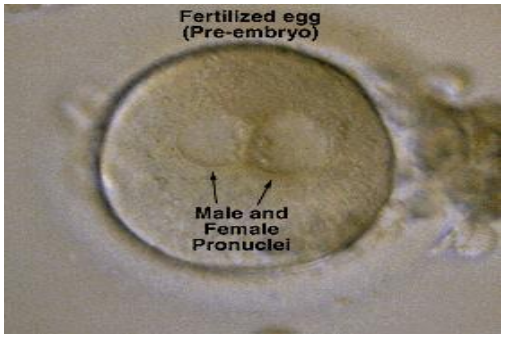
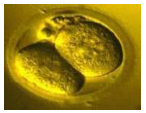
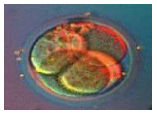
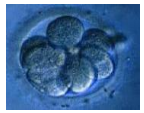
Zygote:

- 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
- **Morula = 32 cells** (Still in the tube), **Blastocyst = 100 cells** (reaches the uterus)



Traveling:

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

Transport of fertilized ovum:

1	2	3
• 3-5 days after fertilization, the zygote reaches uterine cavity	• Transport: fluid current + action of cilia + weak contractions of the fallopian tube	• Isthmus (last 2cm) relaxes under effect of progesterone
4	**5**	
• Delayed transport allows cell division	• Blastocyst (100 cells) enters the uterus	

Transport of fertilized ovum

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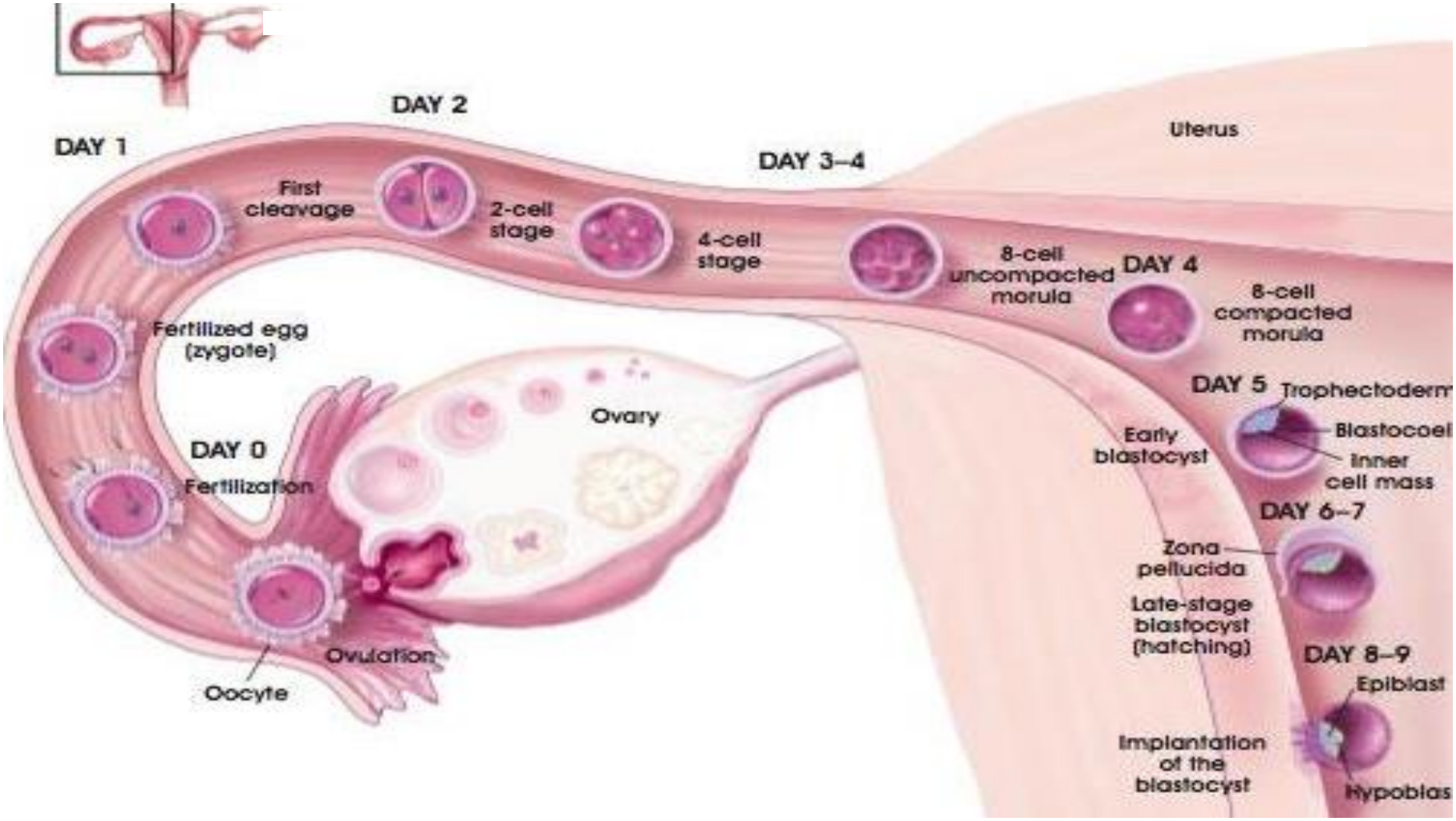
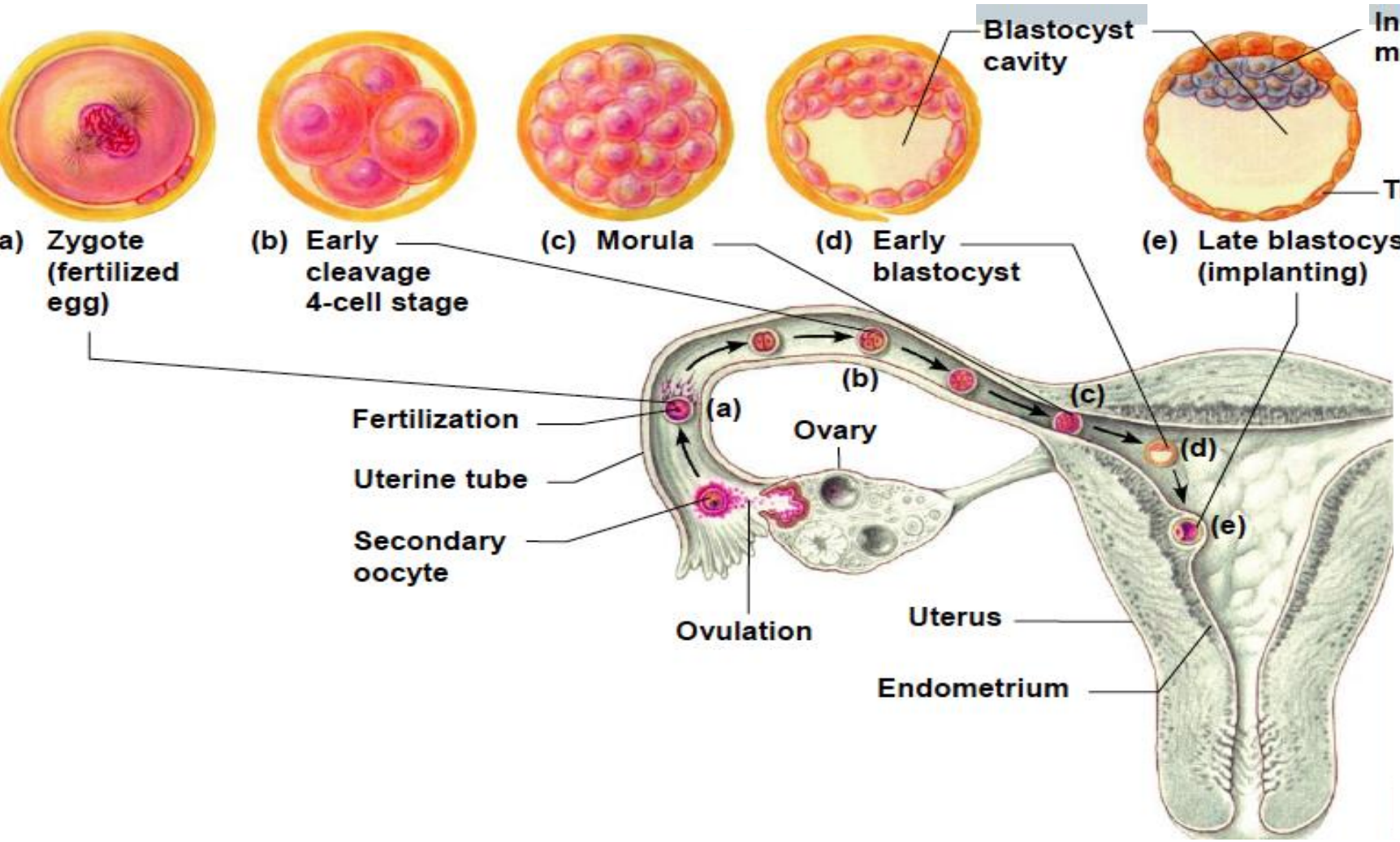
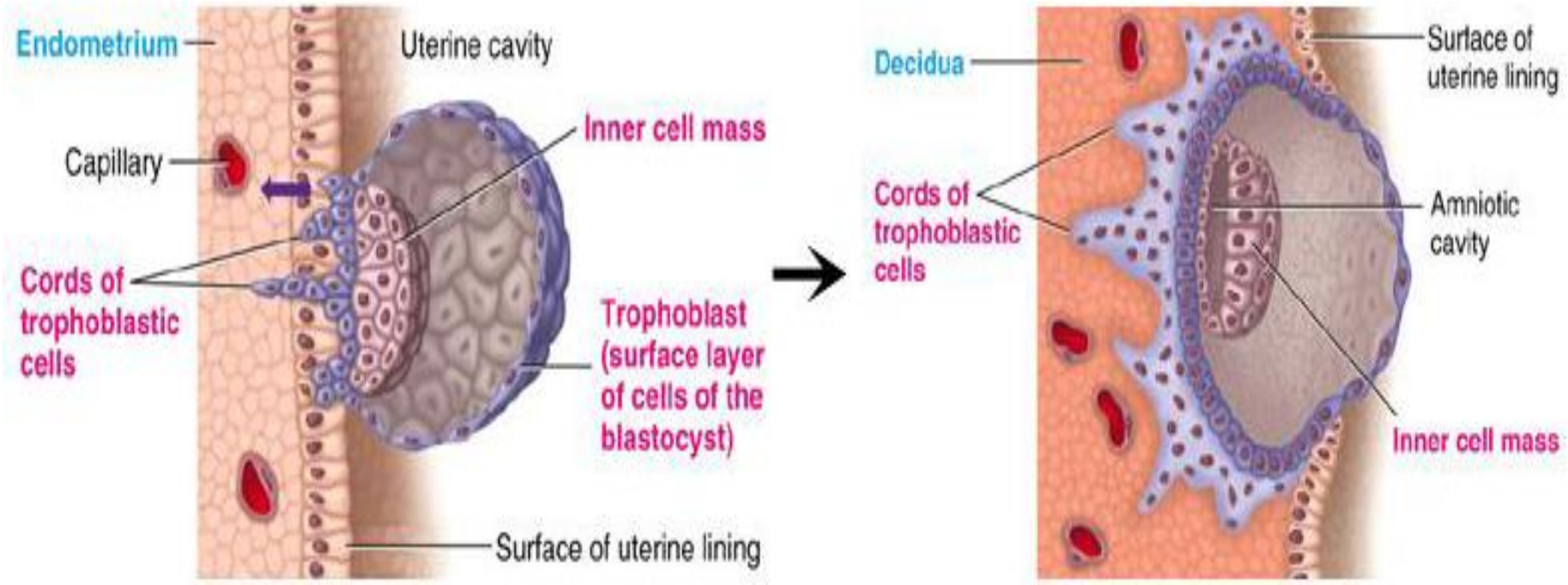


Cleavage

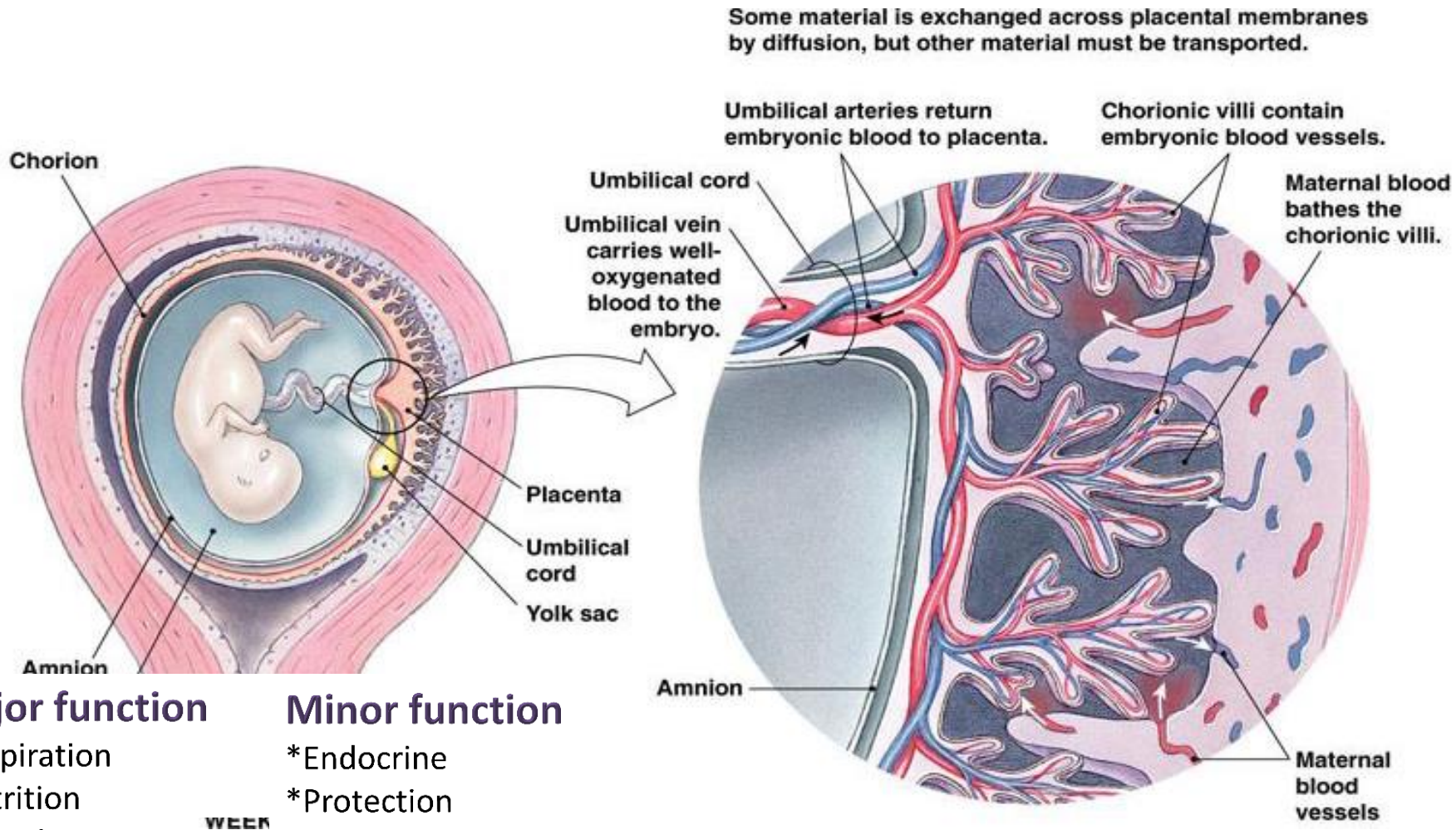

Blastocyst cavity
Inner cell mass
Trophoblast
a) Zygote (fertilized egg)
(b) Early cleavage 4-cell stage
(c) Morula
(d) Early blastocyst
(e) Late blastocyst (implanting)
Fertilization
Uterine tube
Secondary oocyte
Ovulation
Ovary
Uterus
Endometrium
(a)
(b)
(c)
(d)
(e)

Implantation



- Trophoblastic cords from blastocyst
- Blood capillaries grow in the cords
- **21 days after fertilization,** blood starts 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



Major function

*Respiration
*Nutrition
*Excretion

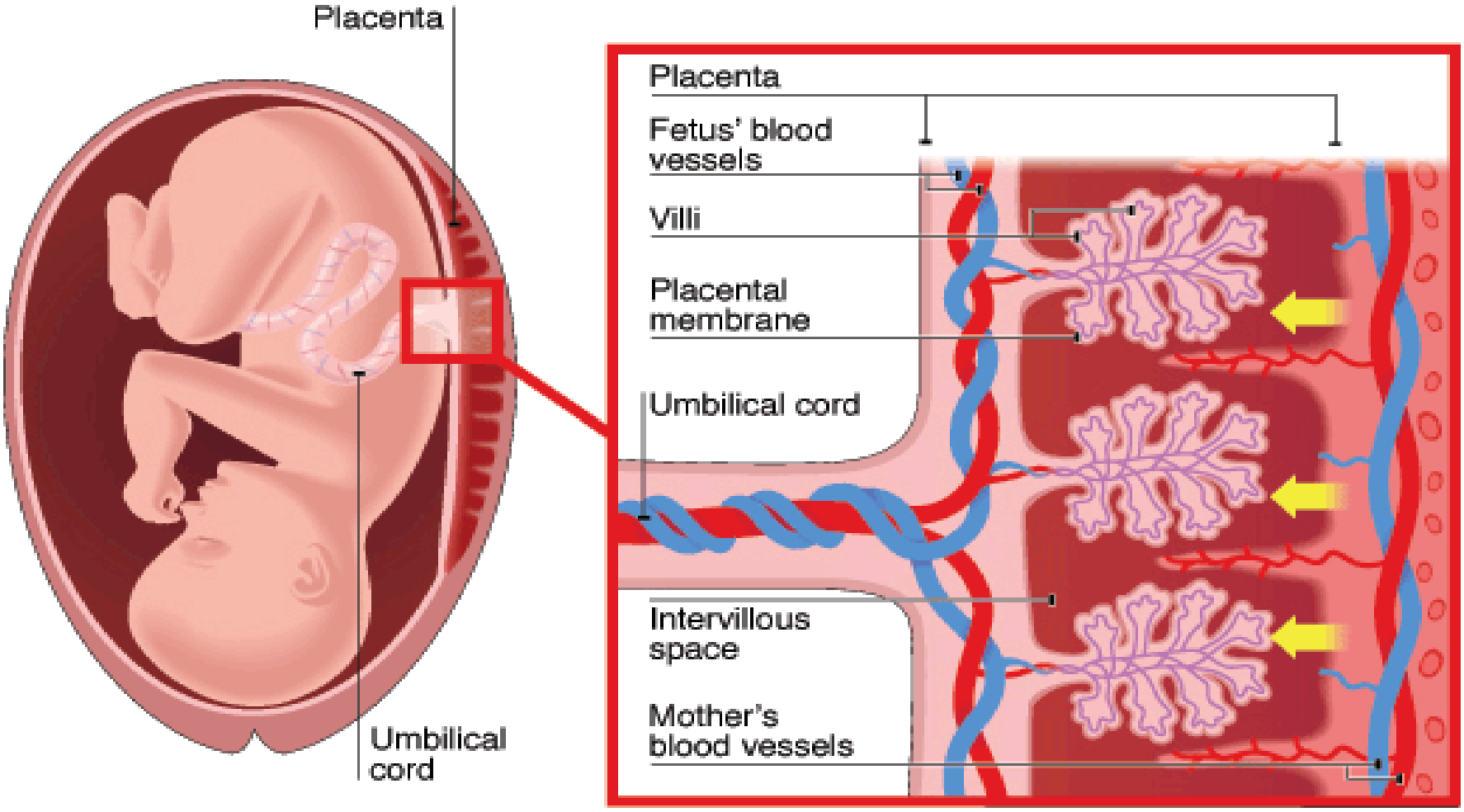
Minor function

*Endocrine
*Protection

WEEK

■ SLIDES ■ IMPORTANT ■ FEMALES' NOTES ■ EXPLANATION ■ MALES' NOTES

Placenta


Placenta
Umbilical cord
Placenta
Fetus' blood vessels
Villi
Placental membrane
Umbilical cord
Intervillous space
Mother's blood vessels

Function of placenta

Important

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Major function of placenta

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
- HbF conc. is 50% higher than HbA in mother
- At low PO2 HbF carries 20-50% more O2 than HbA **(HbF has a higher oxygen carrying capacity than HbA)**
- **pCo2 in the fetus > pCo2 in the mother:** To help the fetus gets rid of Co2 to the mother.
- **pO2 in the fetus < pO2 in the mother:** To help the fetus gets O2 from the mother.

Double Bohr effect (slide #14)

- Low pH in mother's blood **(acidic)** Due to the gaining of Co2 from the fetus.
- High pH in fetal blood **(alkaline)** Due to loss of Co2 to the mother

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

- The maternal blood gains CO2, the pH falls and the curve shifts to the right releasing additional oxygen.
- On the fetal side of the placenta CO2 is lost, the pH rises and the curve shifts to the left allowing additional oxygen uptake.

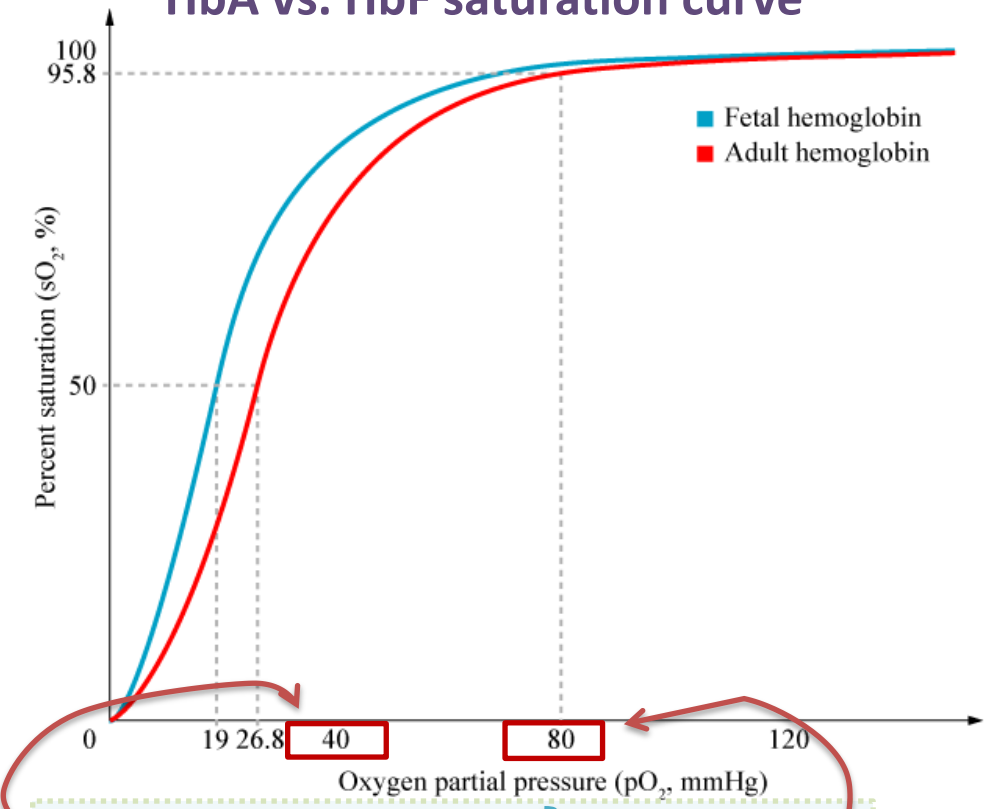
Nutrition

- 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 ensures continuous diffusion of these substances to the maternal blood.

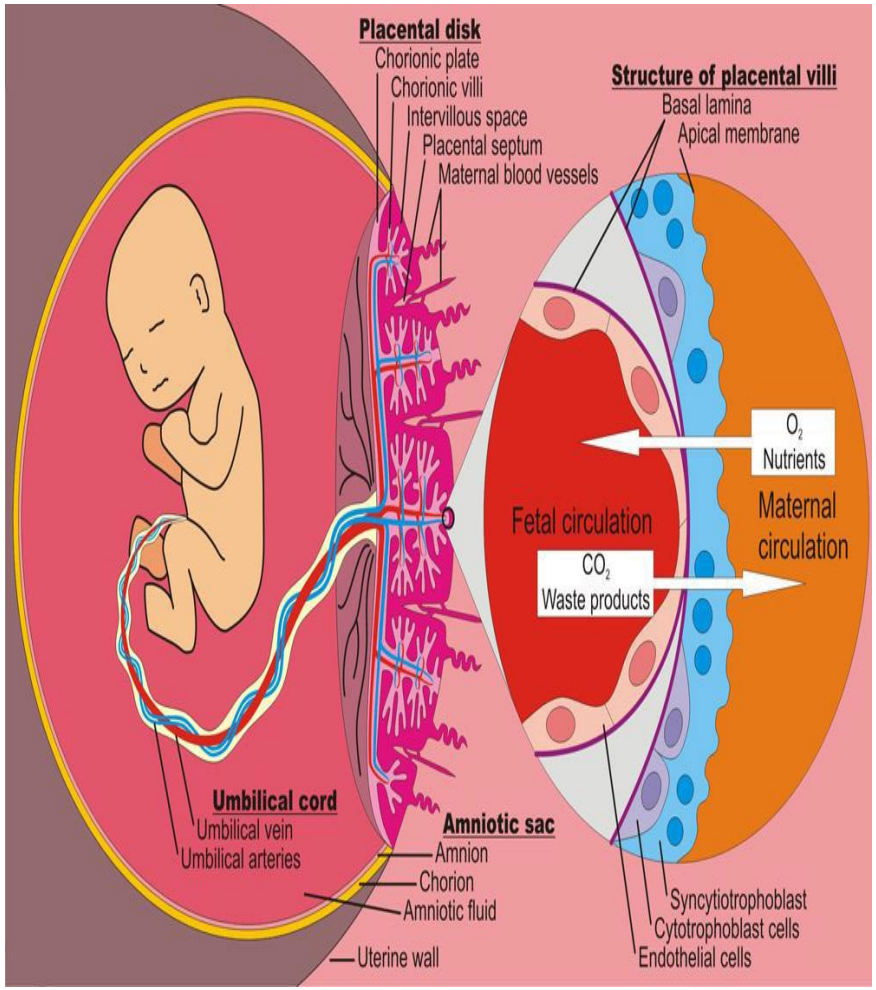
HbA vs. HbF saturation curve



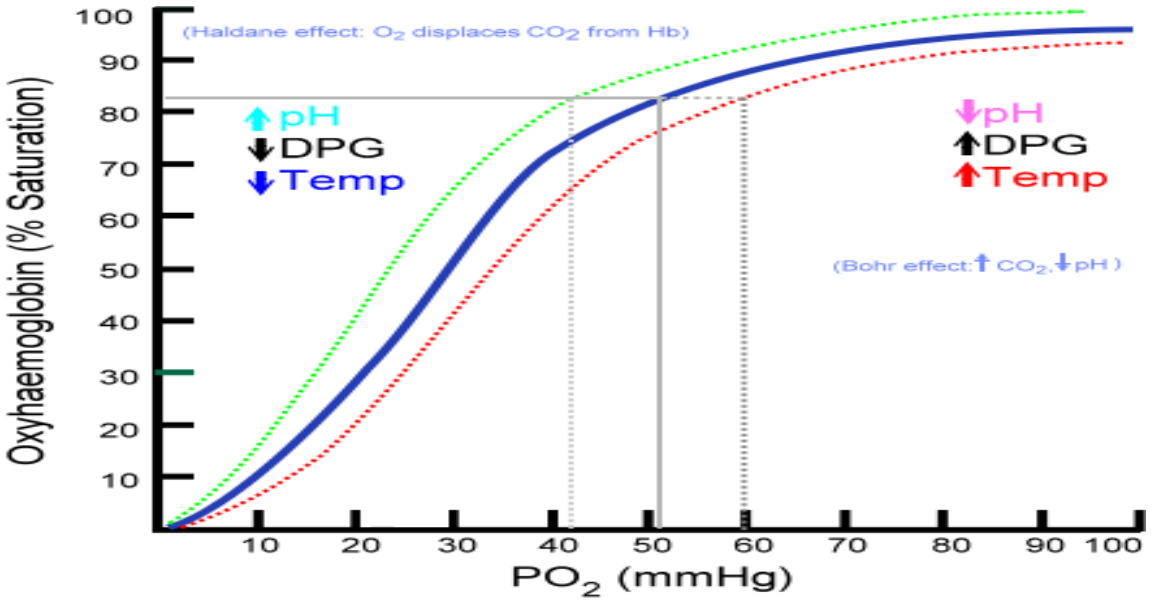
HbF: At lower pO2 (19 pO2)
HbA: at higher pO2 (26.8 pO2)
} 50% saturation

HbF: 80 pO2
HbA: 100 pO2
} 100% saturation

Respiration



Double Bohr effect



Right ⇒ Acidosis
Left ⇒ Alkalosis

- In Acidosis(mother) needs higher pO2
- In Alkalosis(fetus) needs lower pO2 = to reach the same saturation

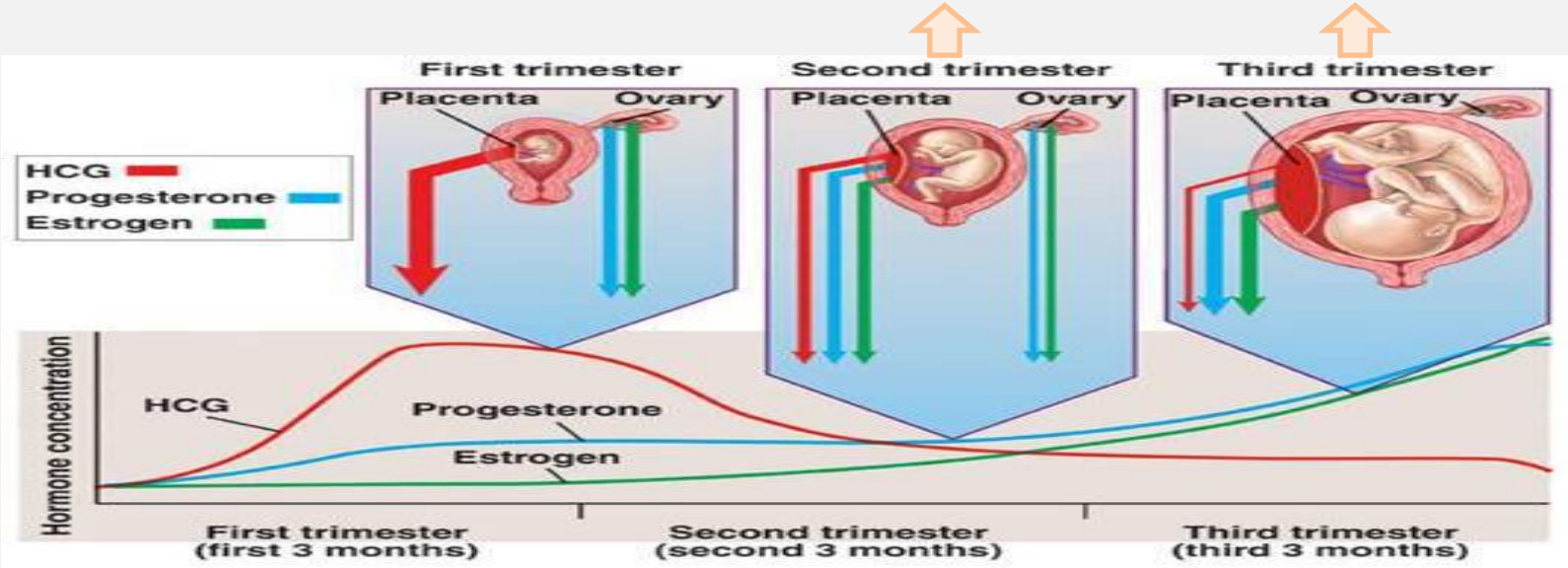
Important factors facilitating delivery of oxygen to the fetal tissues:

- 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.

Minor function of placenta

Endocrine	Protection
1. 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).
- In the first trimester the source of Estrogen and Progesterone is Corpus Luteum.
- In the second and third trimesters the source of Estrogen and Progesterone is the Placenta



Function of placenta..cont.

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Minor function of placenta

Endocrine

2. Estrogen	3. Progsterone	4. Human Chorionic Somatomamotropin or Human placental lactogen (hPL)	5. Relaxin
Functions in the placenta			
• Steroid hormone. • Secreted by syncytial trophoblast cells. • Towards end of pregnancy reaches 30 times. • Derived from weak androgen (DHEA) released from maternal & fetal adrenals cortex.	• Steroid hormone. • Secreted by syncytial trophoblast cells. • Towards end of pregnancy reaches 10 times. • Derived from cholesterol.	• Protein hormone. • Secreted by placenta around 5th gestational week.	• Polypeptide. • Secreted by corpus luteum and placenta.
Functions in the mother			
• Enlargement of uterus, breast & external genitalia. • Relaxation of pelvic ligaments in preparation to labor. • Activation of the uterus (gapjunctions)	• Provides nutrition to developing embryo. • Development of decidual cells. • Inhibits the contractility of the uterus.	• Breast development. • Weak growth hormone's action. • Inhibits insulin sensitivity = decrease glucose utilization Causing gestational diabetes. • Promotes release of fatty acids.	• Relaxation of symphysis pubic ligament (weak). • Softens the cervix at delivery.

hCG level (pregnancy test)

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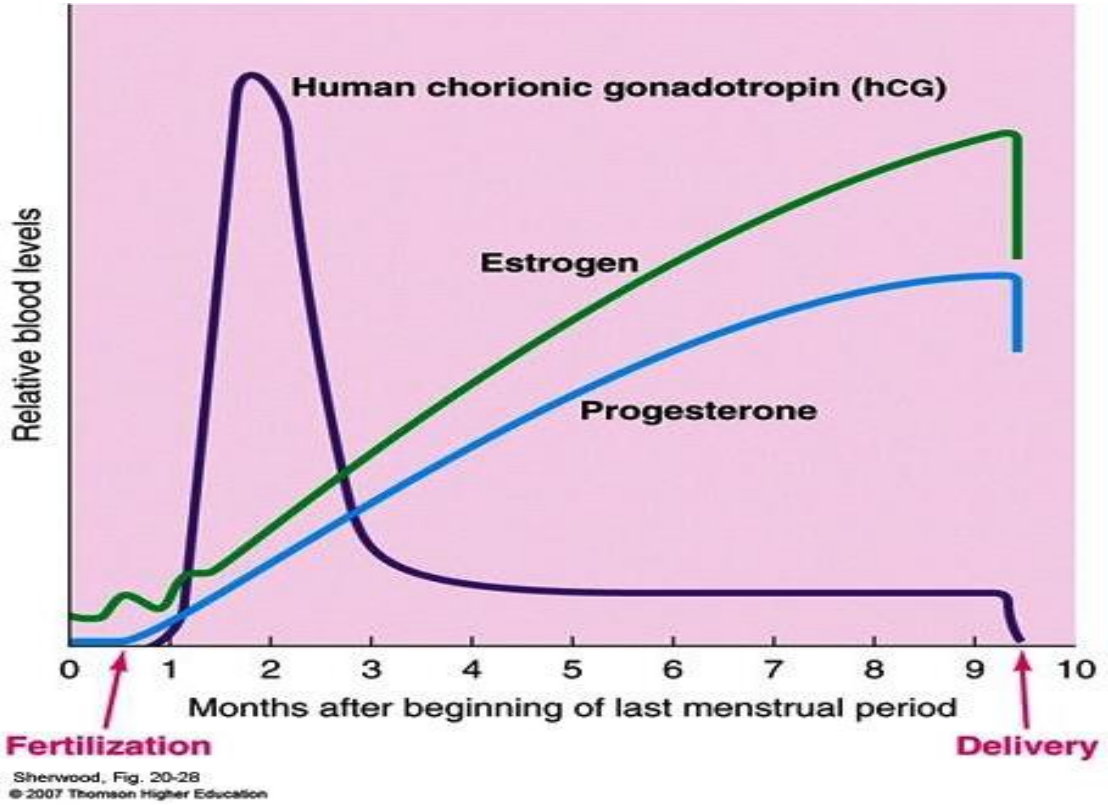
Important

*The hormone human chorionic gonadotropin (better known as hCG) is produced during pregnancy. It is made by cells that form the placenta, which nourishes the egg after it has been fertilized and becomes attached to the uterine wall. Levels can first be detected by a blood test **about 11 days** after conception and **about 12 - 14 days** after conception by a urine test. In general the hCG levels will double **every 72 hours**. The level will reach its peak in the **first 8 – 11 weeks of pregnancy** and then will decline and level off for the remainder of the pregnancy.*



Physiological adaptation to pregnancy

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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). So, the pregnant fluid is more than non-pregnant Preparing the pregnant for losing fluid during labor.
- 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).

15 kg or more considered as pathological.

Increase appetite:

- Removal of food by fetus
- Hormonal effect

Changes in metabolism

- Increase basal metabolic rate (15%)
- Increase in daily requirements for:

Iron, phosphate, calcium & Vitamin

- Vitamin D (Ca+2 absorption)

Changes in respiration

- Increase in O2 consumption (20%)
  - Increase BMR
  - Increase in body size
- Growing uterus presses upwards (restriction)
- Increase in respiratory rate (RR)
- Increase in minute ventilation (TV. RR) by 50%
  - Progesterone ↑ sensitivity of RC to CO2

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)

Fertilization:

Fertilizing sperm >> penetrates Corona Radiata >> Binds to ZP3 receptor >> activates releasing of Hydrolytic enzymes onto Zona Pellucida >> the sperm nucleus enters ovum cytoplasm >> releasing of Ca stored in Cortical Granules >> deactivation of ZP3 receptor >> Block POLYSPERMY.

- Human **fertilization** is the union of a human egg and sperm, usually occurring in **the ampulla** of the uterine tube.
- Zygote begins to divide as it travels through oviduct, delayed transport allows cell division.
- The result of this union is the production of **a Zygote**, or fertilized egg.
- Isthmus relaxes under effect of Progesterone (contracted in the absence of Prgesterone).
- 21 days after fertilization, blood starts to be pumped by fetal heart into the capillaries
- **Major function of placenta:** Respiration, Nutrition and Excretion.
- **The hormone hCG** is produced during pregnancy and then will **decline** and level off for the remainder of the pregnancy.
- Estrogen and progesterone are steroid hormone and secreted by **trophoblast cells.**
- The function of Estrogen is Enlargement of uterus, breast & external genitalia.
- PCo2 higher in fetal than maternal blood, To help the fetus gets rid of Co2 to the mother.
- mother's blood is **acidic** (due to gaining of Co2), fetal blood is **alkaline** (due to loss of Co2)**.**
- important function of hCG is to maintain corpus luteum (↑estrogen & progesterone) till 13-17 weeks of gestation.
- Increase aldosterone level, preparing the pregnant for losing fluid during labor.
- Softens the cervix at delivery and relaxation of symphysis pubic ligament aredue to **Relaxin** hormone.

QUESTIONS

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1. Which one of the physiological changes occurs during pregnancy:

A) Decrese PTH secretion
B) Increase aldosterone
C) The breasts shrink in size
D) Release of FSH and LH increase

2. What is the effect of estrogen on pregnant uterus:

A) Enlargement of uterus
B) Relaxation of pelvic ligaments
C) A+B
D) Inhibits the contractility of the uterus

3. What is the effect of progesteron on pregnant uterus:

A) Increase the contractility of the uterus
B) Enlargement of external genitalia
C) Development of decidual cells
D) A+B

4. In implantation, the blood starts to be pumped by fetal heart into the Capillaries at day……. Atfter fertilization :

A) 18
B) 19
C) 20
D) 21

1	B
2	C
3	C
4	D

5-What is the receptor responsible for sperms in the oocyte?

a) Zp1
b) Zp2
c) Zp3
d) Spermceptor

6- at which days does the fertilized ovum reach the uterine cavity?

a) 1-3
b) 3-5
c) 6-7
d) 8-10

7- the pH of the fetal blood in placenta is?

a) high
b) low
c) Normal
d) Variable

8- hormone that is used to detect pregnancy?

a) GH
b) TH
c) HSG
d) HCG

5	c
6	b
7	a
8	d

THE END

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If there are any Problems or Suggestions, Feel free to contact us:

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THANK YOU

IF YOU WANT TO SHARE ANY INFORMATION REGARDING PHYSIOLOGY OR ANY OTHER SUBJECT .. YOU CAN MENTION THIS ACCOUNT

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