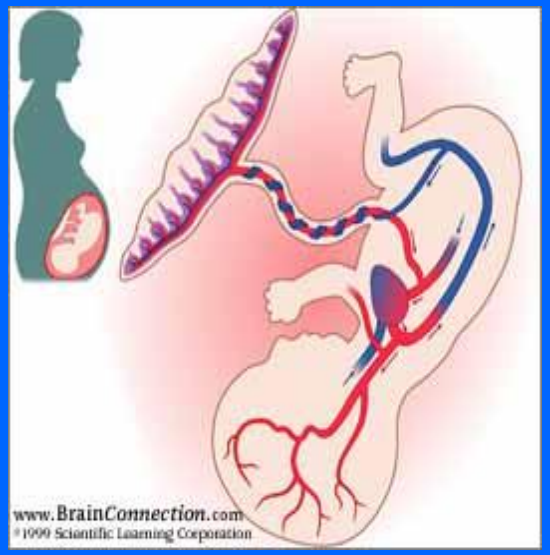
Placental Physiology



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Placental Physiology

Placenta

" apposition or fusion of fetal membranes with the uterine mucosa for the purpose of materno-fetal exchange of nutrients, gases and waste substances"

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Kidney + Lungs + Intestine = Placenta

A bridge between mother and fetus

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Structure (Anatomy)

Functions (Physiology)

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Pregnancy Weeks	11-14	23-26	35-38
Placental Diameter	7 cm	15 cm	22 cm
Placental Weight	65 gm	250 gm	470 gm*
Placental Thickness	1.2 cm	2 cm	2.5 cm
Length of cord	18 cm	40 cm	52 cm**

* 1/6th Birth weight, ** ~ Birth length

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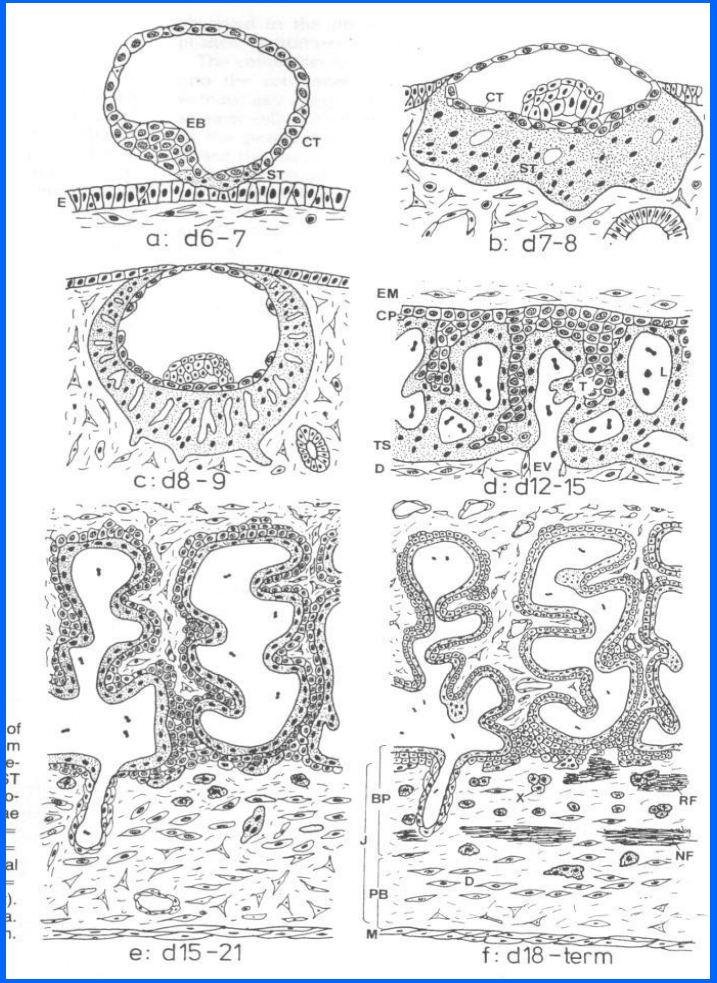
Stages of placental development



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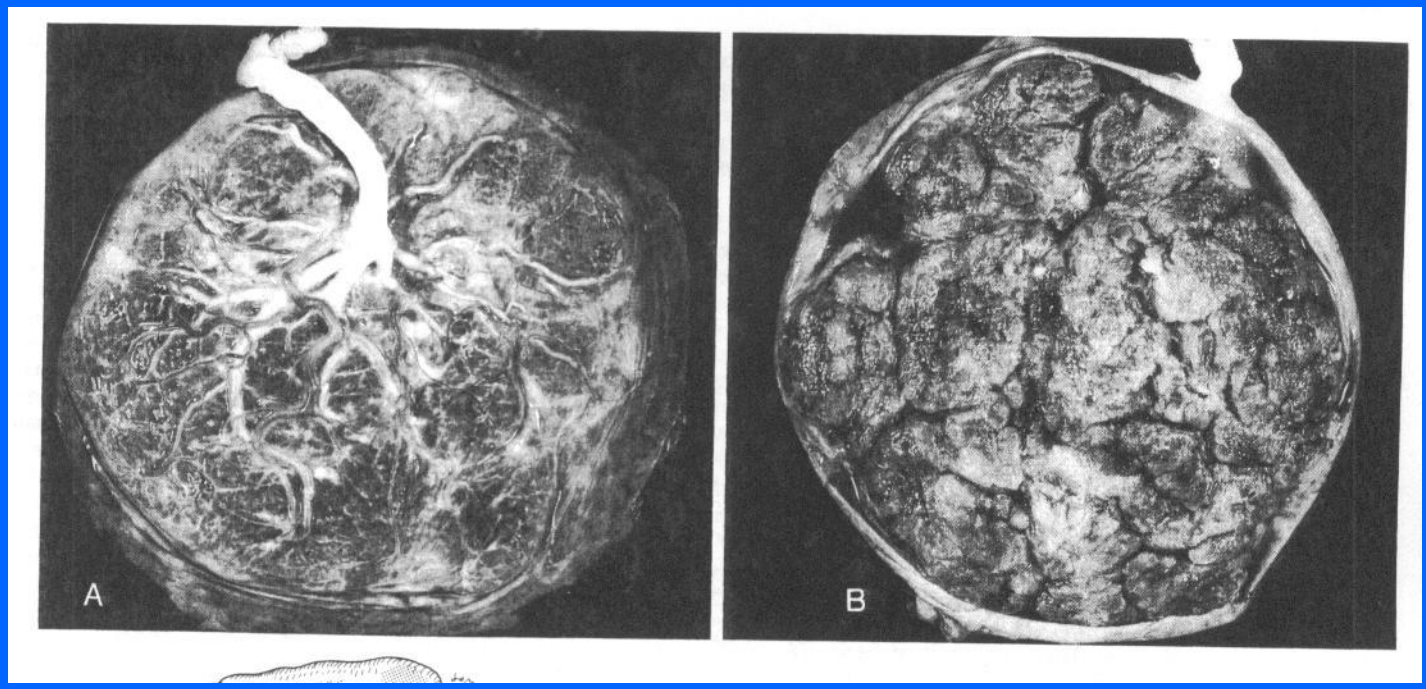
Shape of Placenta (pancake)
Maternal/ Fetal sides (A & B)



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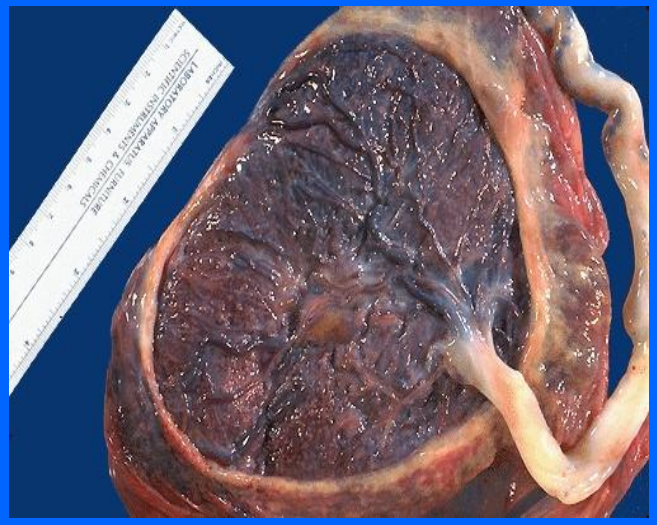
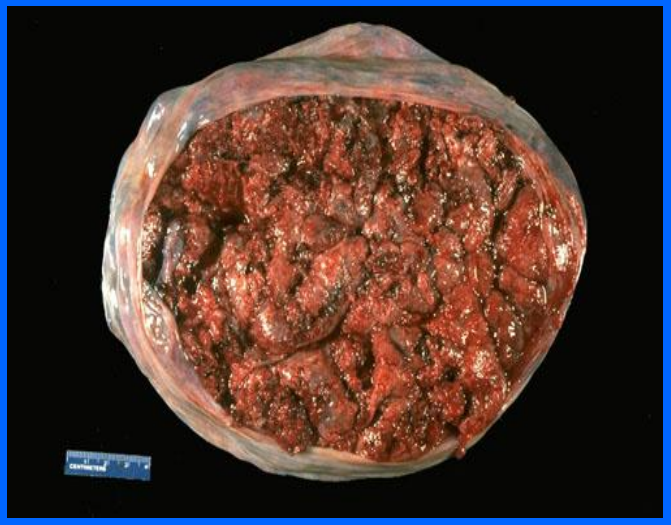
Shape of Placenta (Maternal/ Fetal sides)





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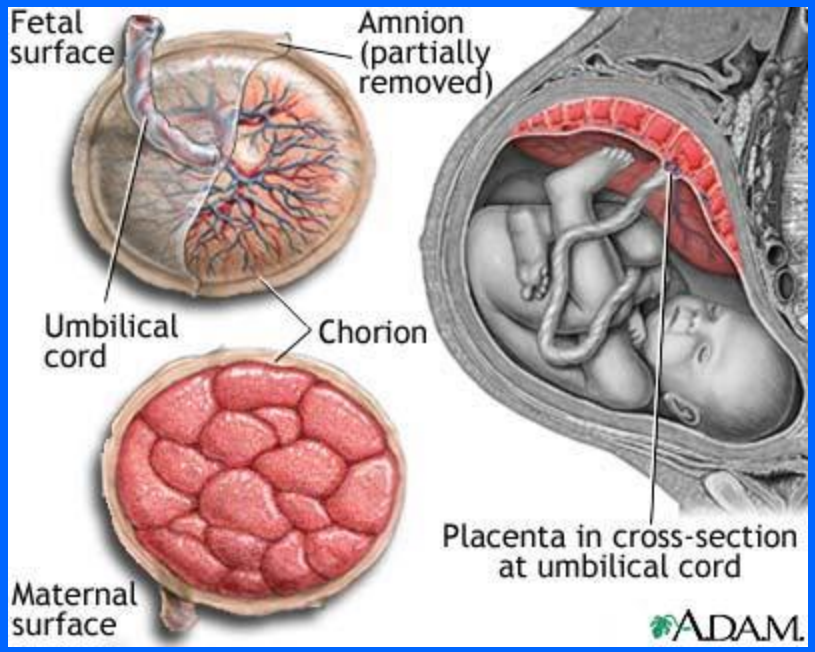
Feto-maternal UNIT (Cotyledon/Placentone 15-20)



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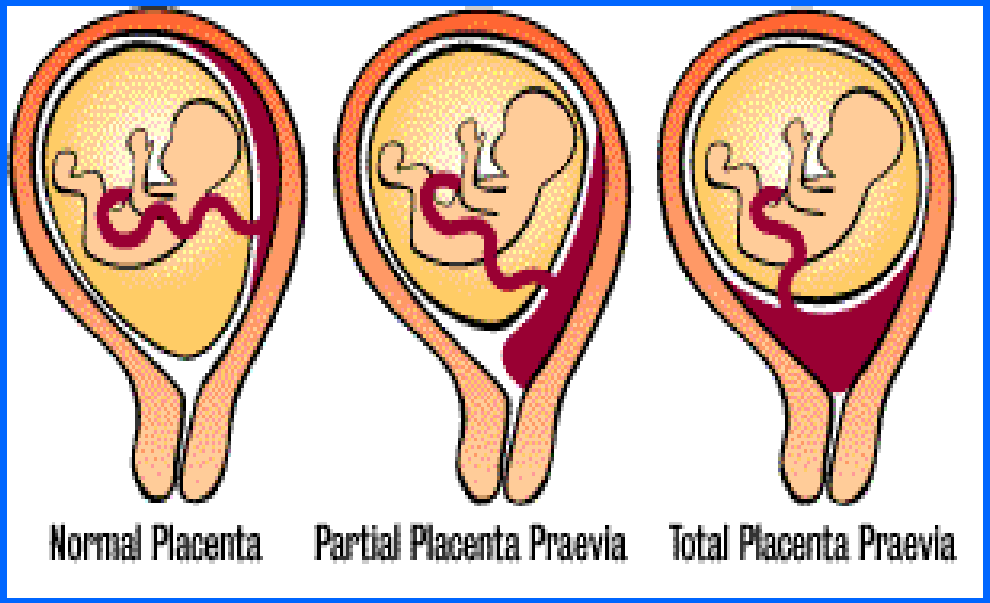
Types of placenta (anatomical)



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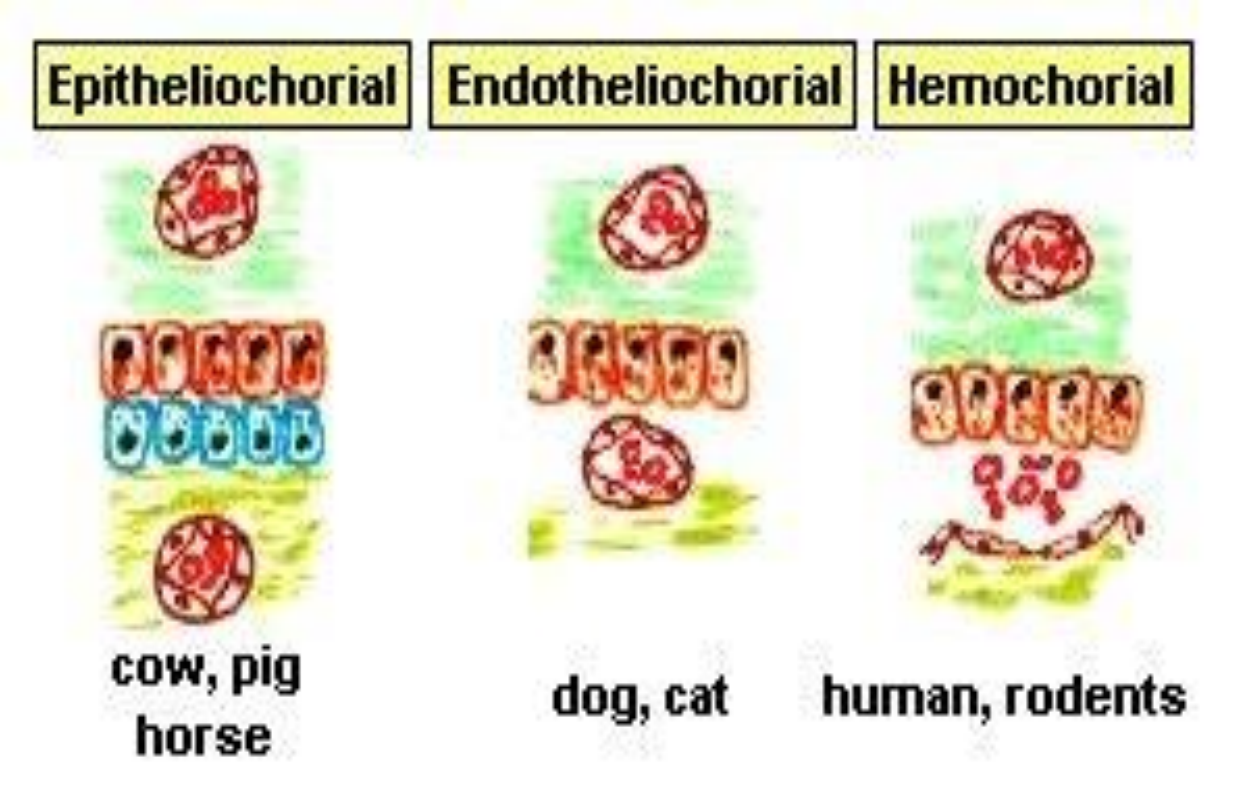
Types of placenta (Functional)



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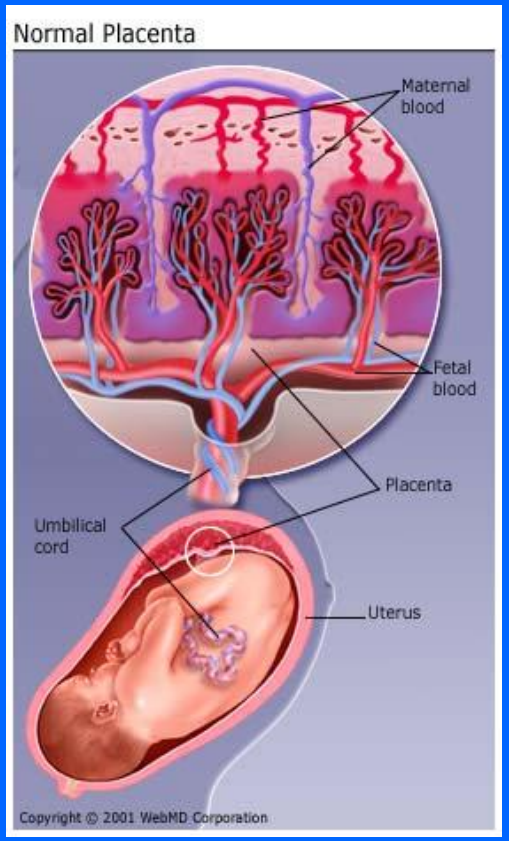
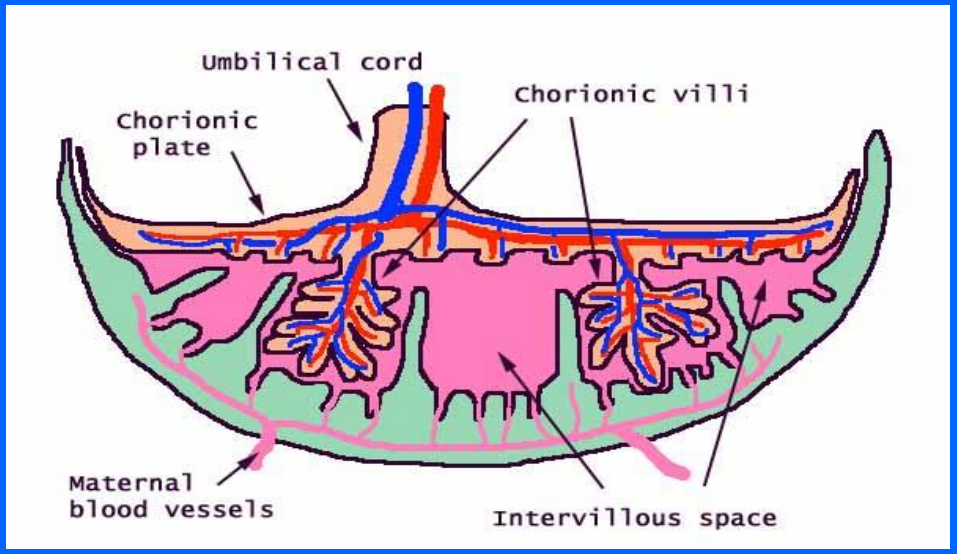
Placental circulation ~ 1 L/min (1/5th of Cardiac output)





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✓ Structure

Functions:

- Gas exchange (Lungs)
- Nutrient supply (Intestine)
- Excretion (Kidney)
- Hormones (Endocrine)
- Barrier (Skin)

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Placental Physiology

Placental Hormones

- Steroids
  - Progestrone
  - Estrogen
- Proteins
  - β HCG
  - Placental lactogens
  - Relaxin

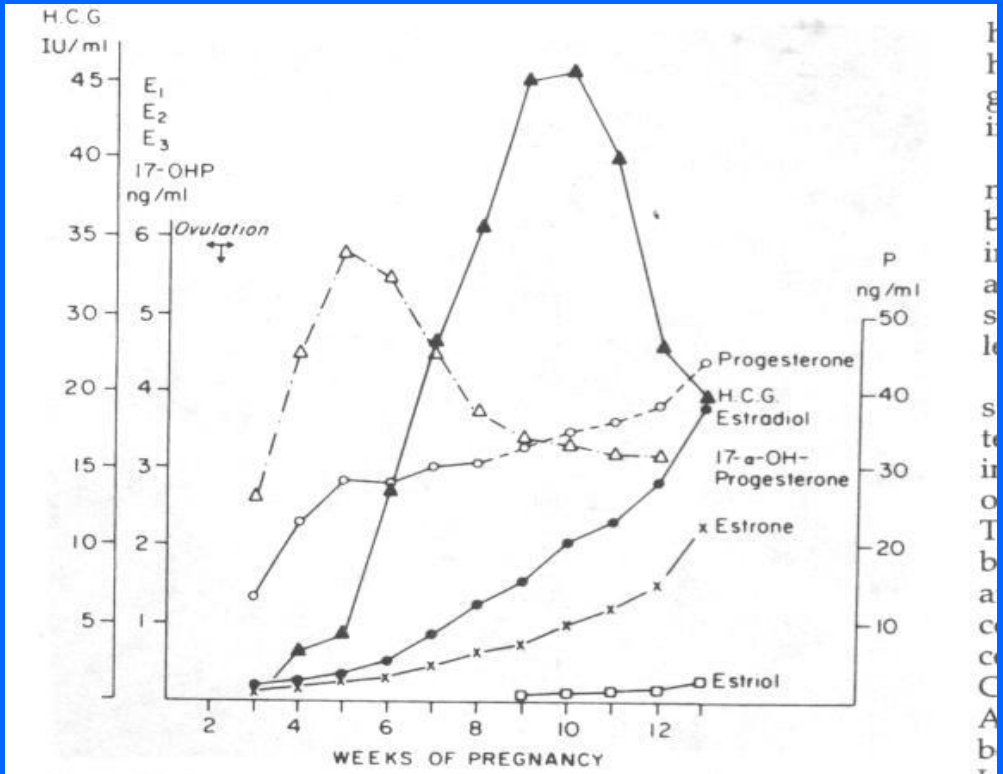

Figure 7–3. Maternal plasma levels of human chorionic gonadotropin (hCG) and steroids during human pregnancy. (From Tulchinsky D, Hobel CJ: Plasma human chorionic gonadotropin, estrone, estradiol, estriol, progesterone and 17α-hydroxyprogesterone in human pregnancy. III. Early normal pregnancy. Am J Obstet Gynecol *117*:884, 1973.)

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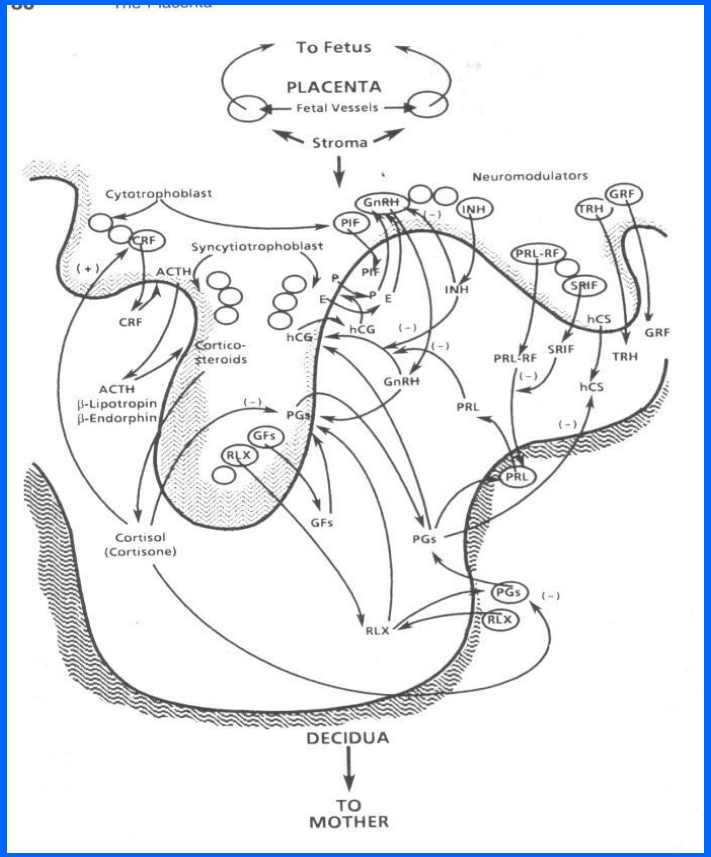
Regulation of hormones



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Mechanism of transfer across placenta

- Diffusion (diffusion coefficient) - Lipophilic
  - Glucose
- Hydrophilic permeability (use porous route) - Lipophobic
  - Inorganic Ions, Na^{+}
- Carrier mediated
  - Energy independent (passive) – with the gradient - D glucose
  - Energy dependent (active) – against the gradient - Amino acid, Ca^{++}
- Flow limited - Oxygen
- Endocytosis - IgG

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Mechanism of transfer of DRUGS across placenta

$$\text{Rate of diffusion} = D \times \Delta c \times \frac{A}{d}$$

D = Diffusion constant

Δ c = Concentration gradient

A = Area of exchange

d = Membrane thickness (inversely proportional)

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Factors affecting transfer of DRUGS across placenta

Lipid solubility

Ionization (non-ionzed-lipophilic- readily cross the placenta)

Protein binding

Molecular weight

$$D_{trans} \propto \frac{\text{Lipid solubility}}{\text{Ionization} \times \text{Protein binding} \times \text{M wt}}$$

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Cross through the placenta

DOES	DOES NOT
Glucose	Insulin
Warfarin	Heparin
IgG	IgM
Bilirubin (unconjugated)	Hormones e.g.
Amino acid	(Glucagon, TSH, ACTH)

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Active transport through the placenta

Amino acid
Vitamin B_{12} (polar)
Iron
Calcium
Dexamethasone
Water soluble vitamins

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Pharmacokinetic concentration time curve

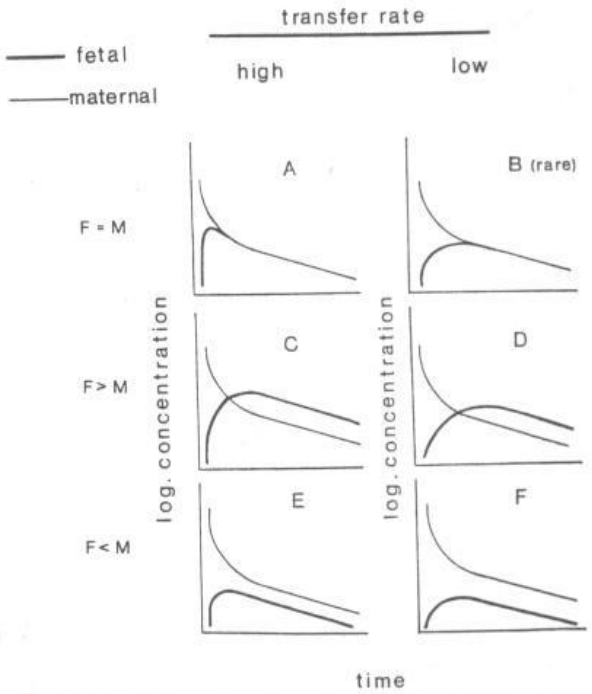

Figure 13–1. Simulation of maternal and fetal plasma concentration time curves from various transplacental pharmacokinetic models. Examples are listed in Table 13–2.

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Pharmacokinetic concentration time curve

Model A/ B: Thiopental, Digoxin, $MgSO_4$

Model C :Valproate, Diazepam, Ampicillin, Penicillin

Model D: Gentamycin, Cephalosporins

Model E: Propranolol, Methadone, Dexamethasone

Model F: Pancuronium, Succinylcholine

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Placental Physiology

Summary

Definition

Structure, development, circulation

Functions (multi-organ)

Transport across placenta (DRUGS)

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Question:

Regarding placental transport all the statements are correct EXCEPT

A. Molecular weight > 1000 limits transport
B. Lipid solubility enhance diffusion
C. Ionized drug diffuses rapidly
D. High protein binding decreases transport
E. Decreased blood flow limits transport

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Placental Physiology

References:

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Fanaroff & Martin

Unadkat et al. Placental drug transporters.
Curr Drug Metab 2004;5:125-131

William Obstetrics

Internet: http://www.google.com/placenta

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