FISIOLOGI
UNIT FETOPLASENTA

Kuliah 9

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Placenta

- Specialized organ of exchange between maternal and fetal blood
- Derived from:
  - trophoblastic tissue, and
  - decidual tissue
- Function: to sustain the growing embryo / fetus during intrauterine life

Formation of Placenta and Amniotic Sac

- **By day 12:**
  - **embryo is completely embedded in decidua**
  - **trophoblastic layer (2 cell layers) thick ⇒ chorion**
- **Chorion continues to release enzymes and expand**
  - **forms extensive network of cavities within decidua**
  - **erodes decidual capillary walls ⇒ maternal blood leaks and fills the cavities**
  - **produces anticoagulant to keep blood clotting**

…..Formation of Placenta and Amniotic Sac

- **Fingerlike projections of chorionic tissue extend into pools of maternal blood**
- **Developing embryo sends out capillaries into chorionic projections to form placental villi:**
  - **some villi extend completely across blood-filled space to anchor fetal portion of placenta to endometrial tissue**
  - **most simply project into pool of maternal blood**

…..Formation of Placenta and Amniotic Sac

- Each placental villus contains embryonic/ fetal capillaries surrounded by a thin layer of chorionic tissue, which separates the embryonic/fetal blood from maternal blood in intervillus spaces ⇒ barrier
- All exchanges between fetal and maternal bloodstreams take place across the extremely thin barrier

…..Formation of Placenta and Amniotic Sac

- **Entire system of interlocking maternal (decidual) and fetal (chorionic) structures makes up the placenta**
- **By 5 weeks after implantation:**
  - **Placenta is well established and operational (even though not fully developed)**
  - **Heart of developing embryo is pumping blood into placental villi as well as to embryonic tissues**

…..Formation of Placenta and Amniotic Sac

- Throughout gestation fetal blood continuously traverses between placental villi and fetus' circulatory system by means:
  - umbilical artery, and
  - umbilical vein

  which are wrapped within umbilical cord
- Maternal blood within placenta:
  - continuously replaced through uterine arterioles
  - percolates through intervillus spaces, where it exchanges substances with fetal blood in the surrounding villi
  - exits through uterine vein

…..Formation of Placenta and Amniotic Sac

- **During the time of implantation and early placental development:**
  - **inner cell mass forms a fluid-filled amniotic cavity between chorion and portion of inner cell mass destined to become fetus**
  - **epithelial layer that encloses amniotic cavity is called amniotic sac or amnion**

…..Formation of Placenta and Amniotic Sac

- As it continues to develop, amniotic sac eventually fuses with chorion, forming a single combined membrane that surrounds embryo / fetus
- Amniotic fluid (fluid in amniotic cavity) which is similar in composition to normal extracellular fluid, surrounds and cushions fetus throughout gestation

Functions of Placenta

- **Transport system between maternal blood and fetal blood:**
  - **Nutrition & O_2 and metabolic wastes & CO_2**
  - **Drugs, pollutants, cigarette smokes, chemical agents, microorganisms $\Rightarrow$ harmful (thalidomide, AIDS, drug abuse)**
- **Temporary endocrine organ:**

  Fetally derived portion has remarkable capacity to secrete peptide and streoid hormones for maintaining pregnancy

Placenta As Endocrine Organ

As major endocrine organ of pregnancy placenta is unique in 2 regards

1. **It is a transient tissue**
2. **Secretion of its hormones is not subject to extrinsic control. Type and rate of placental hormone secretion depend primarily on stage of pregnancy**

…..Placenta As Endocrine Organ

Placental hormones which play critical roles in maintaining pregnancy:

- **Human chorionic gonadotropin (hCG)**
- **Estrogen**
- **Progesterone**
- **Human chorionic somatomammotropin (hCS)**
- **Relaxin**
- **Parathyroid hormone-related peptide (PTHrp)**

Human Chorionic Gonadotropin

- Peptide hormone, secreted by developing chorion
- Functionally similar to LH: stimulates and maintains CL $\Rightarrow$ CL pregnancy.

  It is important because LH is suppressed by high levels of progesterone.
- In male fetus: also stimulates Leydig cells to secrete testosterone for masculinizing the developing reproductive tract

.....Human Chorionic Gonadotropin

- Secretion rate increases rapidly during early pregnancy. Peak secretion 60 days after end of last menstrual period

  CL pregnancy partially regresses as hCG secretion dwindles, but not converted into scar tissue until after delivery of baby

- Eliminated from body through urine $\Rightarrow$ pregnancy diagnoses test can detect hCG as early as about 2 weeks after first menstrual period

.....Human Chorionic Gonadotropin

- **Morning sickness:**
  - **A frequent early clinical sign of pregnancy**
  - **A daily bout of nausea and vomiting that often occurs in the morning but can take place at any time of day**
  - **Usually appears shortly after implantation**
  - **Coincides with the time of peak hCG production ⇒ scientist speculate hCG may trigger this symptoms, perhaps by acting on chemoreceptor trigger zone in vomiting center**

Estrogen and Progesterone

Important question:

- **Why doesn't the developing placenta start producing estrogen and progesterone in the first place instead of secreting hCG which in turn stimulates CL to secrete these 2 critical hormones?**

…..Estrogen and Progesterone

The answer is that:

- **Placenta cannot produce enough estrogen and progesterone in 1st trimester of pregnancy**
- **For different reasons between estrogen and progesterone**

…..Estrogen and Progesterone

In case of estrogen:

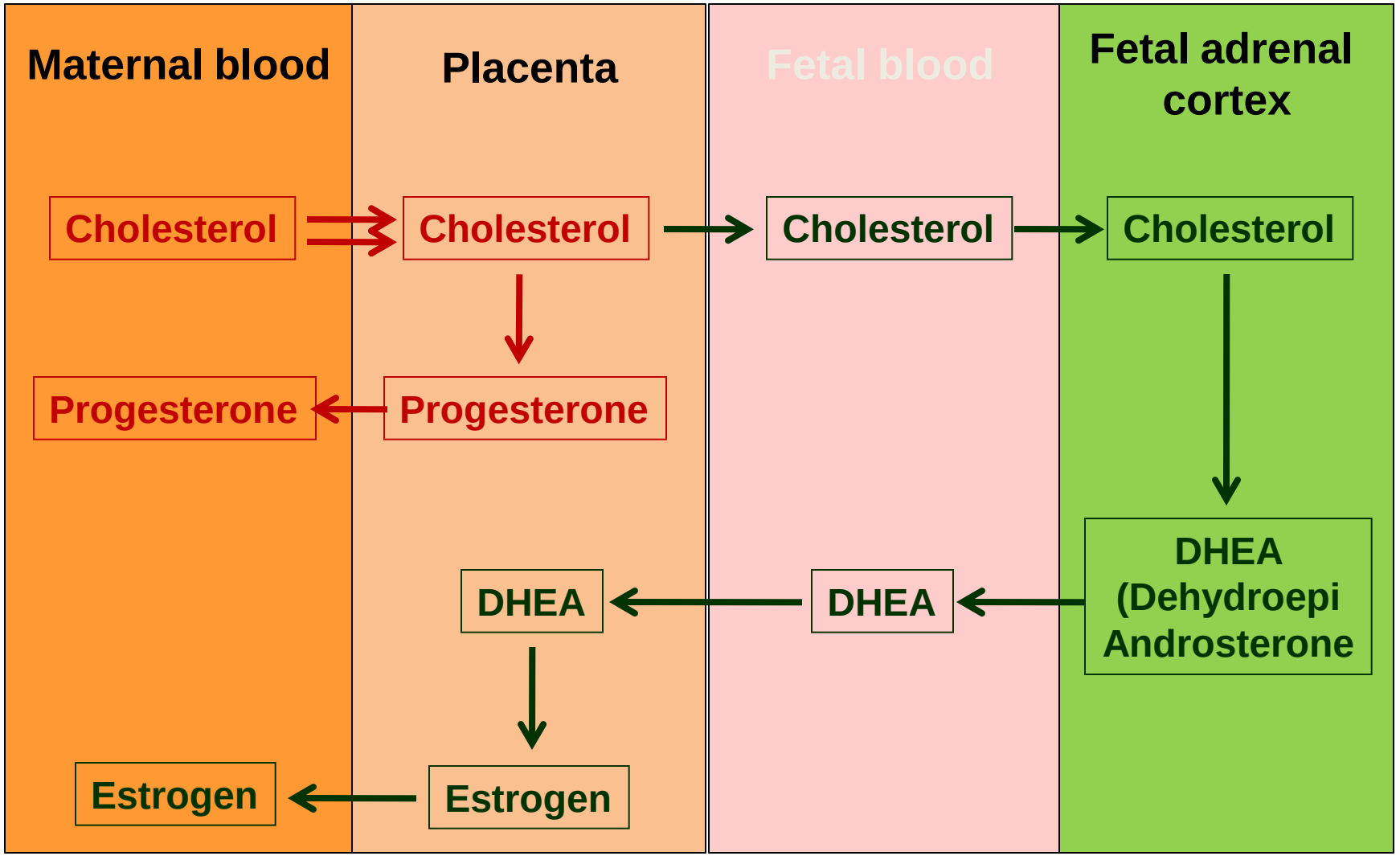
- **Estrogen synthesis requires complex interaction between placenta and fetus**
- **Placenta converts dehydroepiandrosterone (DHEA) from fetal adrenal cortex into estriol ⇒ measurement of estriol levels in maternal urine can be used to assess viability of fetus**

…..Estrogen and Progesterone

In case of progesterone:

- Early placenta has enzymes necessary to convert cholesterol from maternal blood into progesterone ⇒ so that progesterone can be synthesized soon after implantation
- However, progesterone produced is proportional to placental weight ⇒ in first 10 weeks not enough progesterone produced
- Increase in circulating progesterone reflects placental growth

…..Estrogen and Progesterone



Roles of Estrogen During Pregnancy

- Estrogen stimulates growth of myometrium which increase in size throughout pregnancy. Stronger uterine musculature is needed to expel fetus during labor
- Estriol also promotes development of ducts within mammary glands, through which milk will be ejected during lactation

Roles of Progesterone During Pregnancy

- Main function is suppressing contractions of uterine myometrium to prevent miscarriage
- Promoting formation of mucus plug in cervical canal to prevent vaginal contaminants from reaching uterus
- Stimulating development of milk glands in breast, in preparation for lactation

Human Chorionic Somatomammotropin

- **hCS has structure similar to GH and prolactin, and exerts similar actions, that is thought responsible for:**
  - **Decreased use of glucose by mother and mobilization of free fatty acids from maternal adipose stores (similar to GH) ⇒greater quantities of glucose and fatty acids available for shunting to fetus**
  - **Helps prepare mammary glands for lactation (similar to prolactin)**

Relaxin

- Also secreted by CL of pregnancy
- Functions:
  - Soften cervix in preparation cervical dilation at parturition ⇒ VT: one of signs of pregnancy
  - Loosens connective tissue between pelvic bones in preparation for parturition

Parathyroid Hormone-Related Peptide

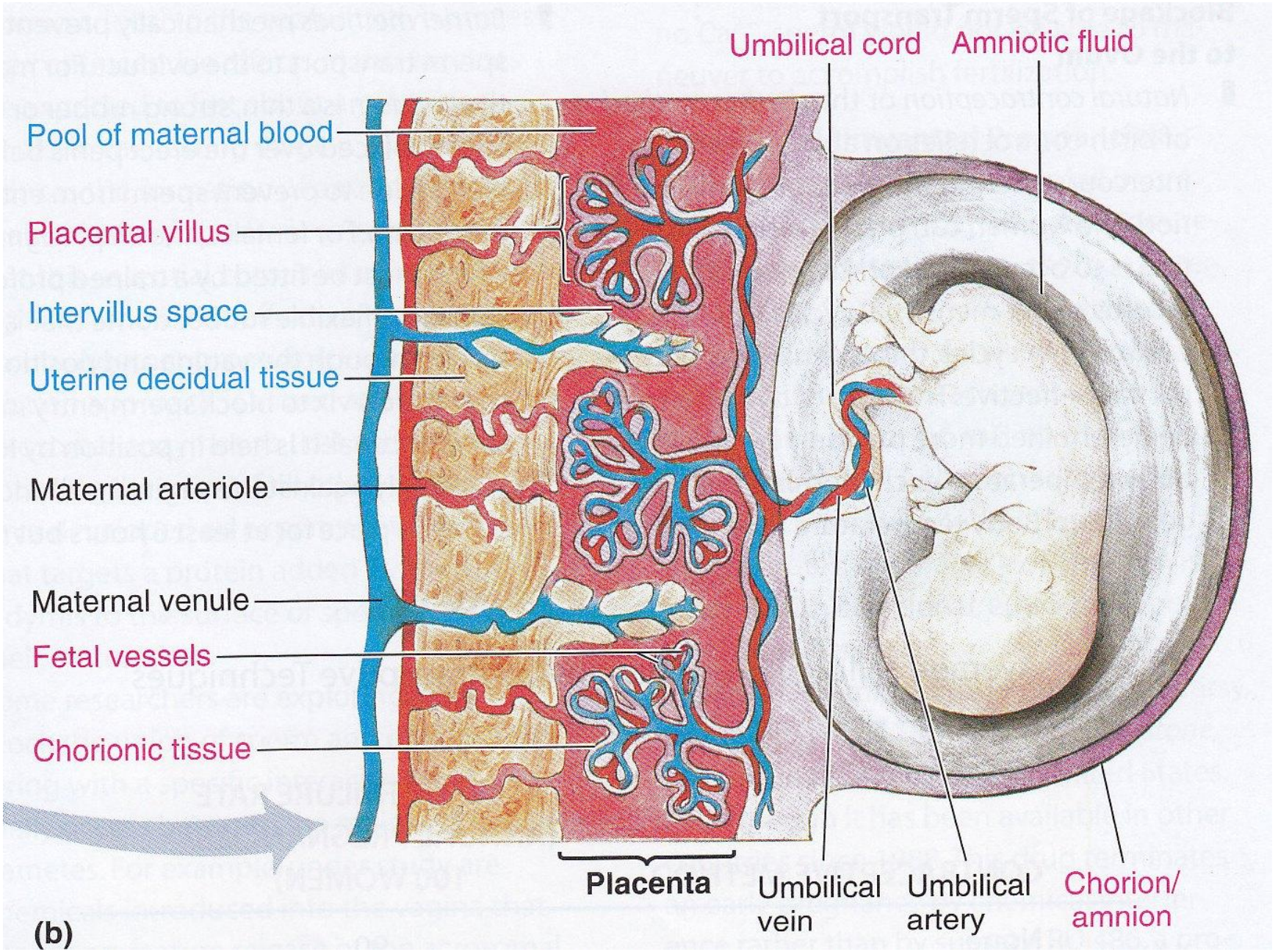
- **PTHrp has structure similar to parathyroid hormone (PTH) and exerts similar actions:**
  - **Mobilized Ca^{2+} from maternal bones to ensure adequate calcification of fetal bones**
  - **PTHrp is important, especially in case of mother doesn't consume enough Ca^{2+}**

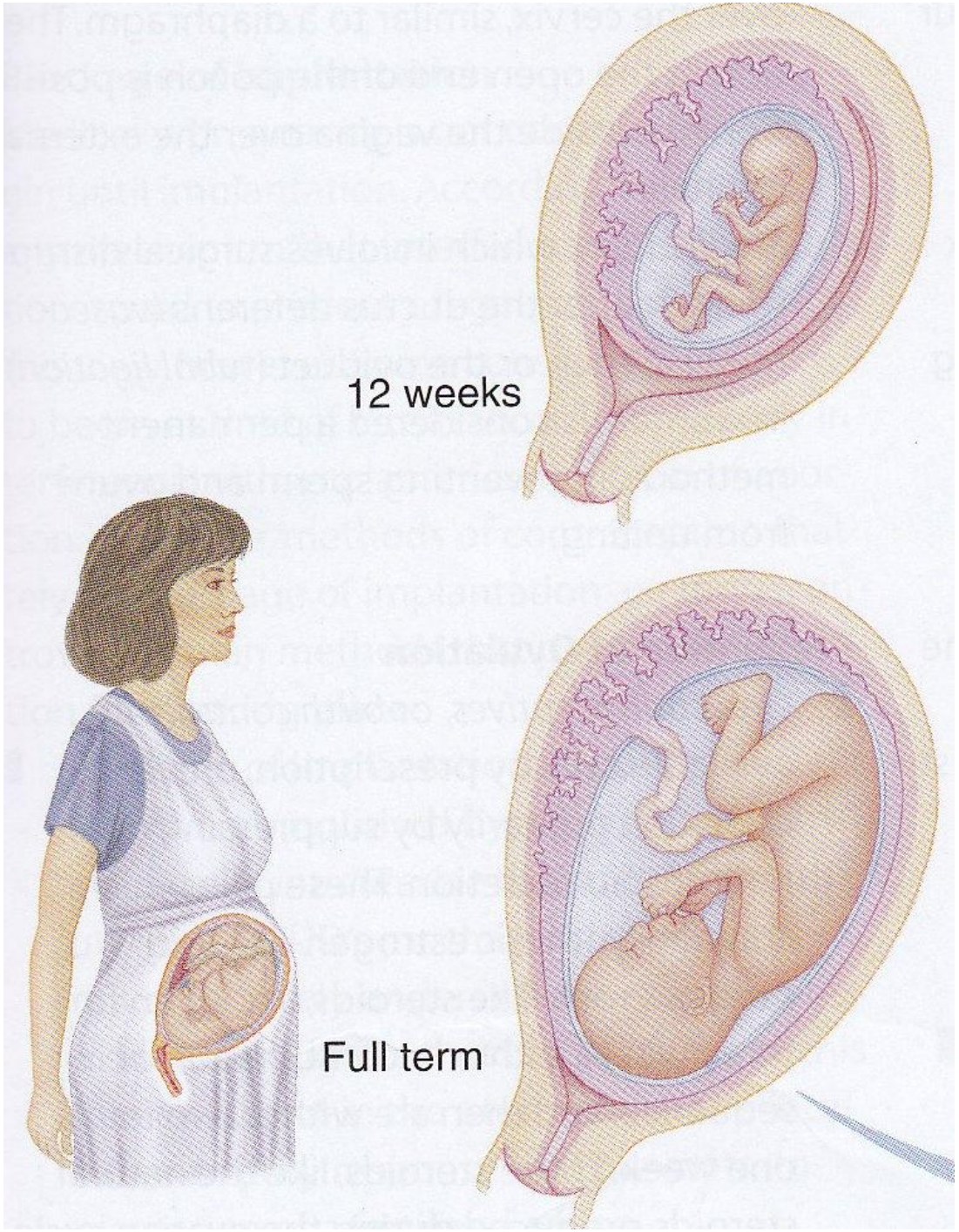
Placental Hormones

HORMONES	FUNCTION
1. Human chorionic gonadotropin (hCG)	- Maintains CL of pregnancy - Stimulates secretion of testosterone by developing testes in XY embryo
2. Estrogen	- Stimulates growth of myometrium, increasing uterine strength for parturition - Helps prepare mammary glands for lactation
3. Progesterone	- Suppresses uterine contraction to provide a quiet environment for fetus - Promotes formation of cervical mucus plug to prevent uterine contamination - Helps prepare mammary glands for lactation

.....Placental Hormones

HORMONES	FUNCTION
4. Human Chorionic Somatomammo tropin (hCS) similar to GH and prolactin	- Believed to reduce maternal use of glucose and to promote breakdown of stored fat so that greater quantities of glucose and free fatty acids may be shunted to fetus - Helps prepare mammary glands for lactation
5. Relaxin	- Soften cervix in preparation cervical dilation at parturition - Loosens connective tissue between pelvic bones in preparation for parturition
3. Placental PTHrp (Parathyroid Hormone-related peptide	- Increases maternal plasma Ca^{2+} level for use in calcifying fetal bones, if necessary promotes localized dissolution of maternal bones, mobilizing their Ca^{2+} stores for use by developing fetus


Umbilical cord
Amniotic fluid
Pool of maternal blood
Placental villus
Intervillus space
Uterine decidual tissue
Maternal arteriole
Maternal venule
Fetal vessels
Chorionic tissue
Placenta
Umbilical vein
Umbilical artery
Chorion/ amnion
(b)


12 weeks
Full term

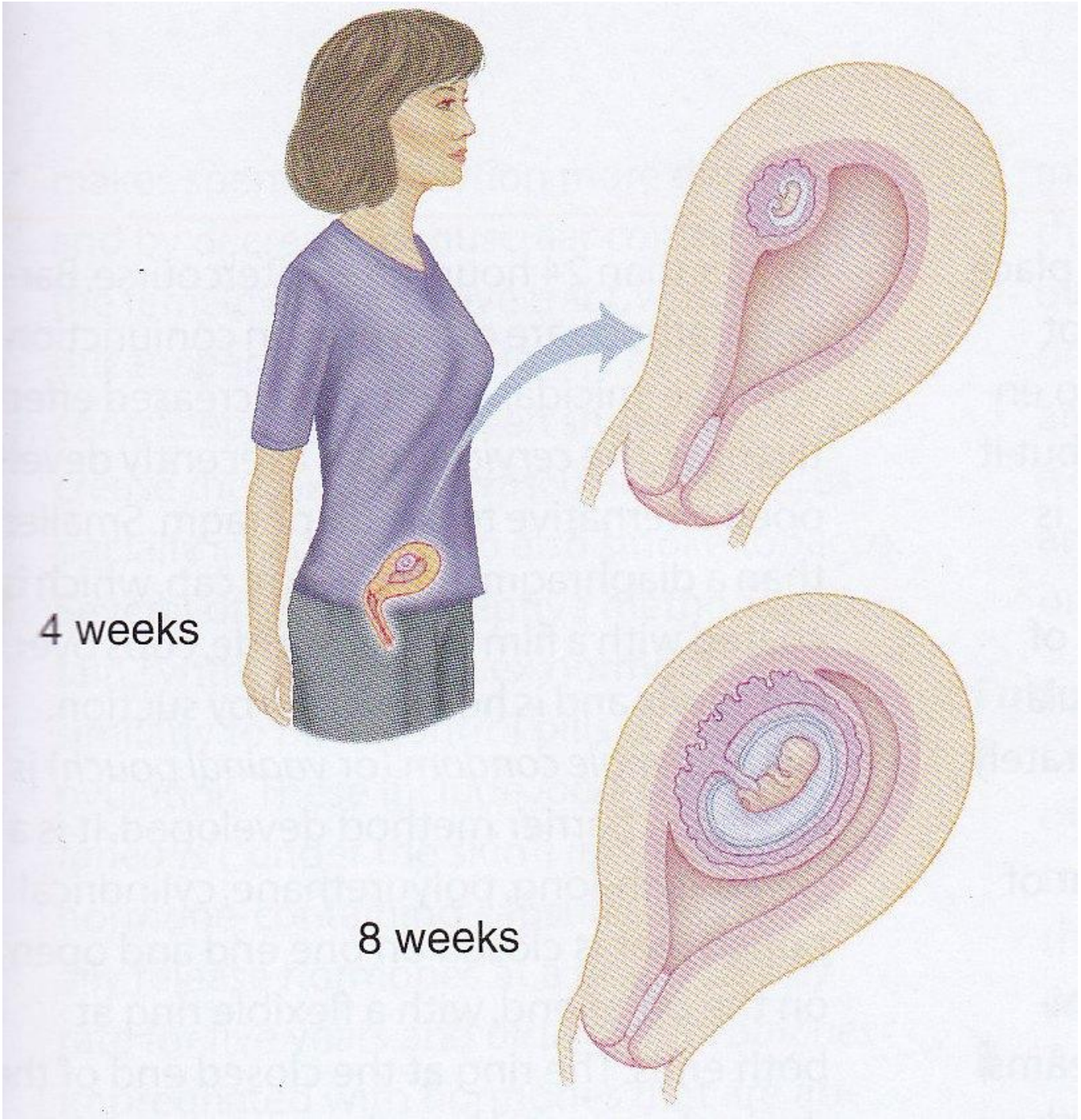

4 weeks
8 weeks

FIGURE 20-27

A human fetus surrounded by the amniotic sac. The fetus is near the end of the first trimester of development.


Thank You