Pregnancy and Human Development

From Egg to Embryo

- Pregnancy – events that occur from fertilization until the infant is born
- Conceptus – the developing offspring
- Gestation period – from the last menstrual period until birth
- Preembryo – conceptus from fertilization until it is two weeks old
- Embryo – conceptus during the third through the eighth week
- Fetus – conceptus from the ninth week through birth

From Egg to Embryo

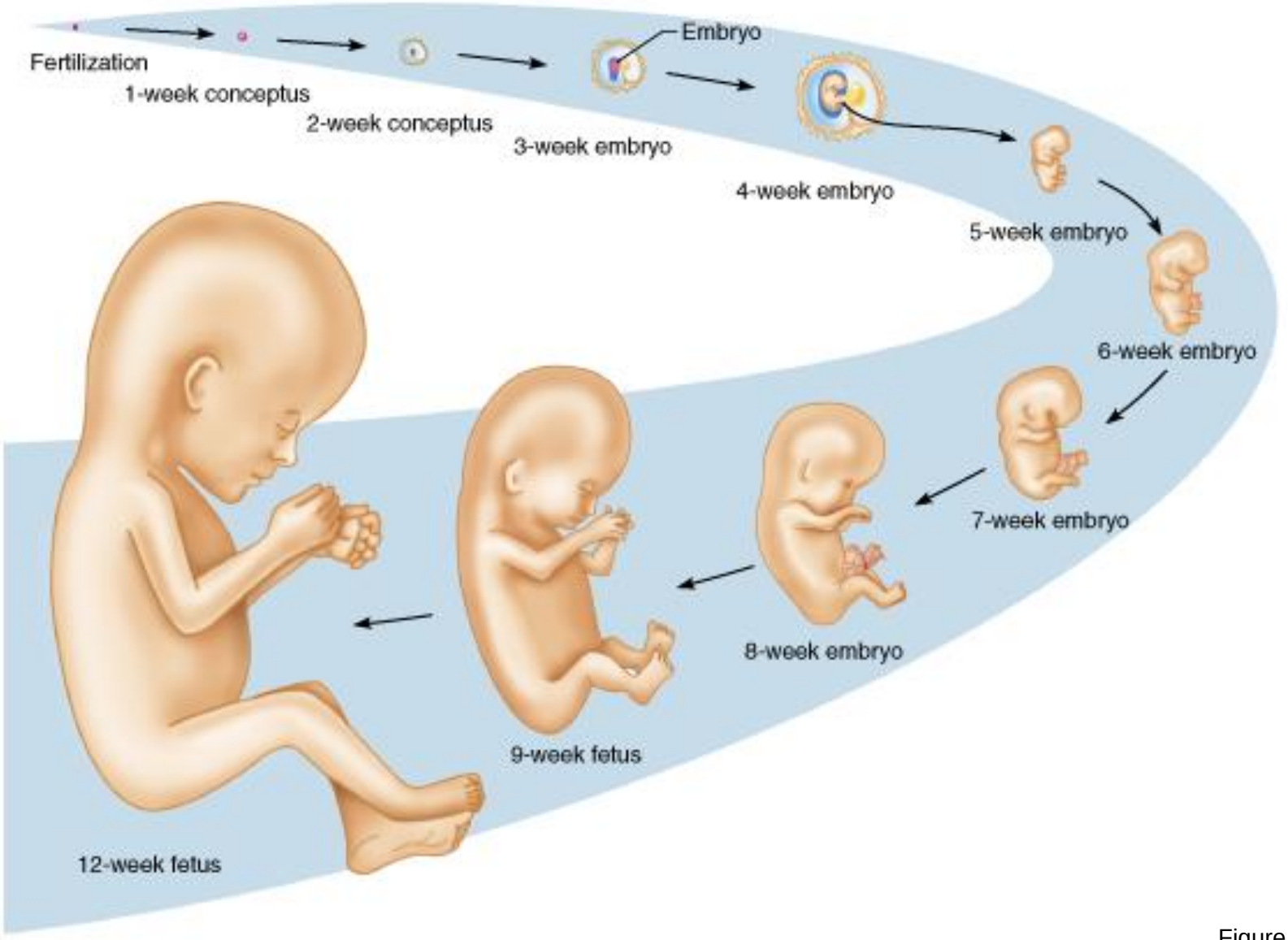


Figure 29.1

Accomplishing Fertilization

- The oocyte is viable for 12 to 24 hours
- Sperm is viable 24 to 72 hours
- For fertilization to occur, coitus must occur no more than:
  - Three days before ovulation
  - 24 hours after ovulation
- Fertilization – when a sperm fuses with an egg to form a zygote .it occurs **in midportion of uterine tube**

Sperm Transport and Capacitation

- Fates of ejaculated sperm include:
  - Leak out of the vagina immediately after deposition
  - Destroyed by the acidic vaginal environment
  - Fail to make it through the cervix
  - Dispersed in the uterine cavity or destroyed by phagocytic leukocytes
  - Reach the uterine tubes
- Sperm must undergo capacitation before they can penetrate the oocyte

Acrosomal Reaction and Sperm Penetration

- An ovulated oocyte is encapsulated by :
  - The corona radiata
  - The zona pellucida
- Sperm binds to the zona pellucida and undergoes the acrosomal reaction
  - Enzymes are released near the oocyte
  - Hundreds of acrosomes release their enzymes to digest the zona pellucida

***Fertilization of ovum by sperm in midportion of uterine tube**

Sperms - own motility - tail

Ovum - passive muscle contractions, secretes sperm attractant

*** 50-100 sperms contact zona pellucida bind to sperm receptor (ZP3)**

Acrosomal reaction (breakdown of acrosom-lysosome like organelle , release of enzymes; acrosin – penetration of sperm through zona pellucida)

Acrosomal Reaction and Sperm Penetration

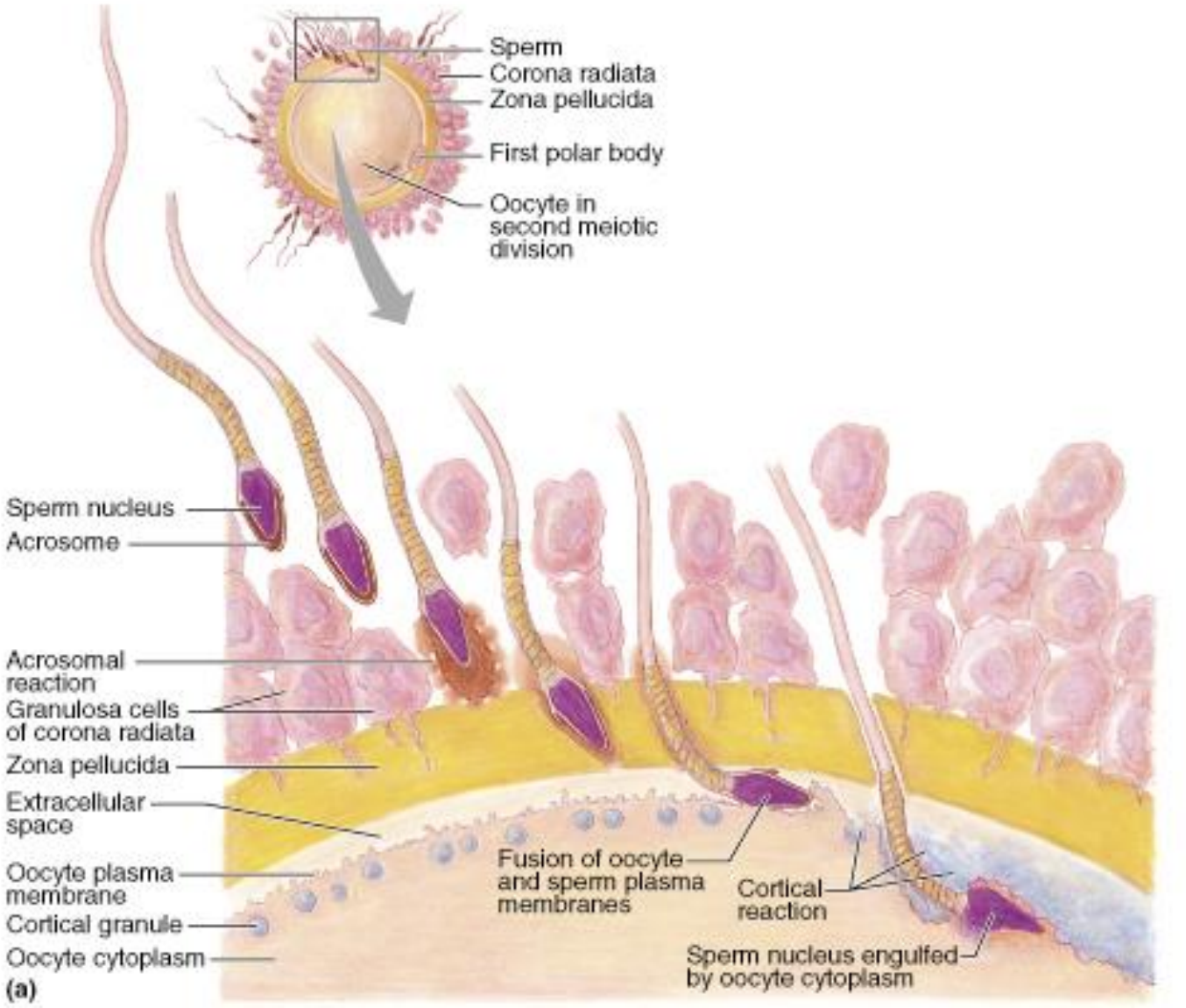


Figure 29.2a

Blocks to Polyspermy

- Only one sperm is allowed to penetrate the oocyte
- Two mechanisms ensure monospermy
  - Fast block to polyspermy – membrane depolarization prevents sperm from fusing with the oocyte membrane
  - Slow block to polyspermy
    - The cortical granules release enzymes that destroy sperm receptors
    - These enzymes cause sperm already bound to receptors to detach

Completion of Meiosis II and Fertilization

- Upon entry of sperm, the secondary oocyte:
  - Completes meiosis II
  - Casts out the second polar body
- The ovum nucleus swells, and the two nuclei approach each other
- When fully swollen, the two nuclei are called *pronuclei*
- Fertilization – when the pronuclei come together

Completion of Meiosis II and Fertilization

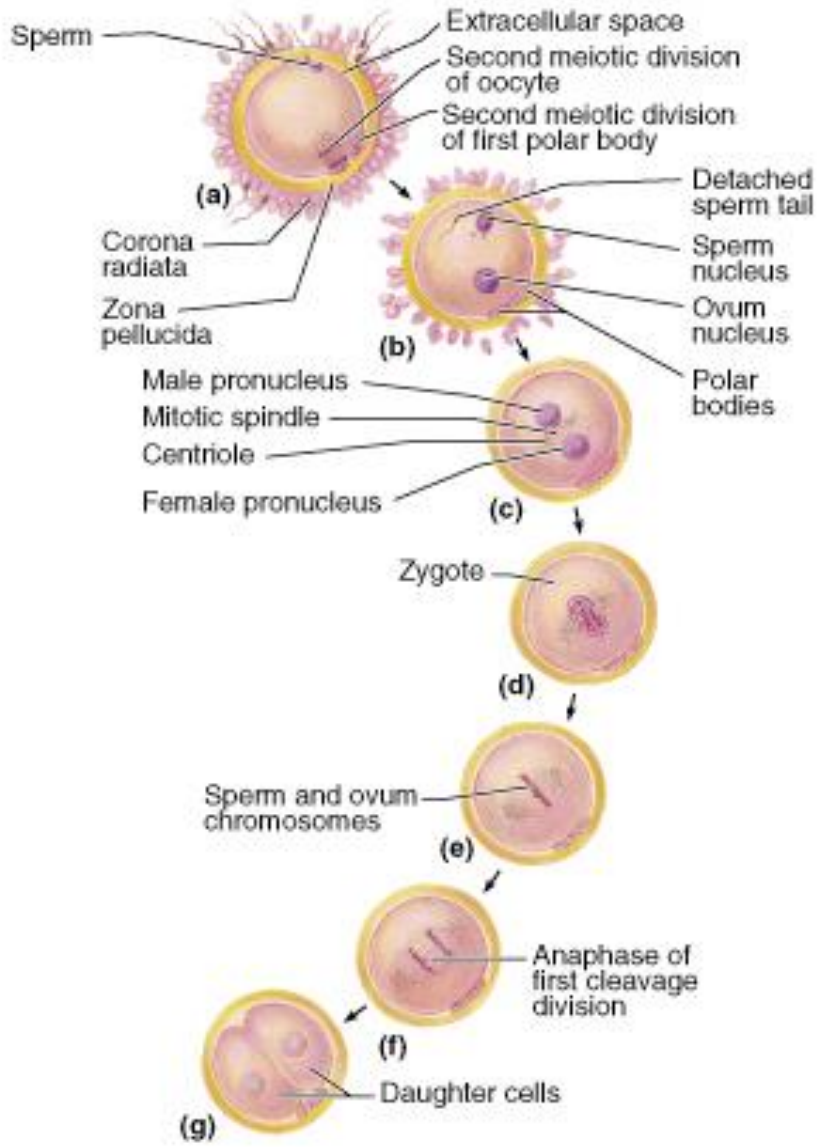


Figure 29.3a-g

Preembryonic Development

- The first cleavage produces two daughter cells called *blastomeres*
- Morula – the 16 or more cell stage (72 hours old)
- By the fourth or fifth day the preembryo consists of 100 or so cells (blastocyst)
- Blastocyst – a fluid-filled hollow sphere composed of:
  - A single layer of trophoblasts
  - An inner cell mass
- Trophoblasts take part in placenta formation
- The inner cell mass becomes the embryonic disc

Implantation

- Begins six to seven days after ovulation when the trophoblasts adhere to the endometrium
- The trophoblasts then proliferate and form two distinct layers
  - Cytotrophoblast – cells of the inner layer that retain their cell boundaries
  - Syncytiotrophoblast – cells in the outer layer that lose their plasma membranes and invade the endometrium
- The implanted blastocyst is covered over by endometrial cells
- Implantation is completed by the fourteenth day after ovulation

Implantation

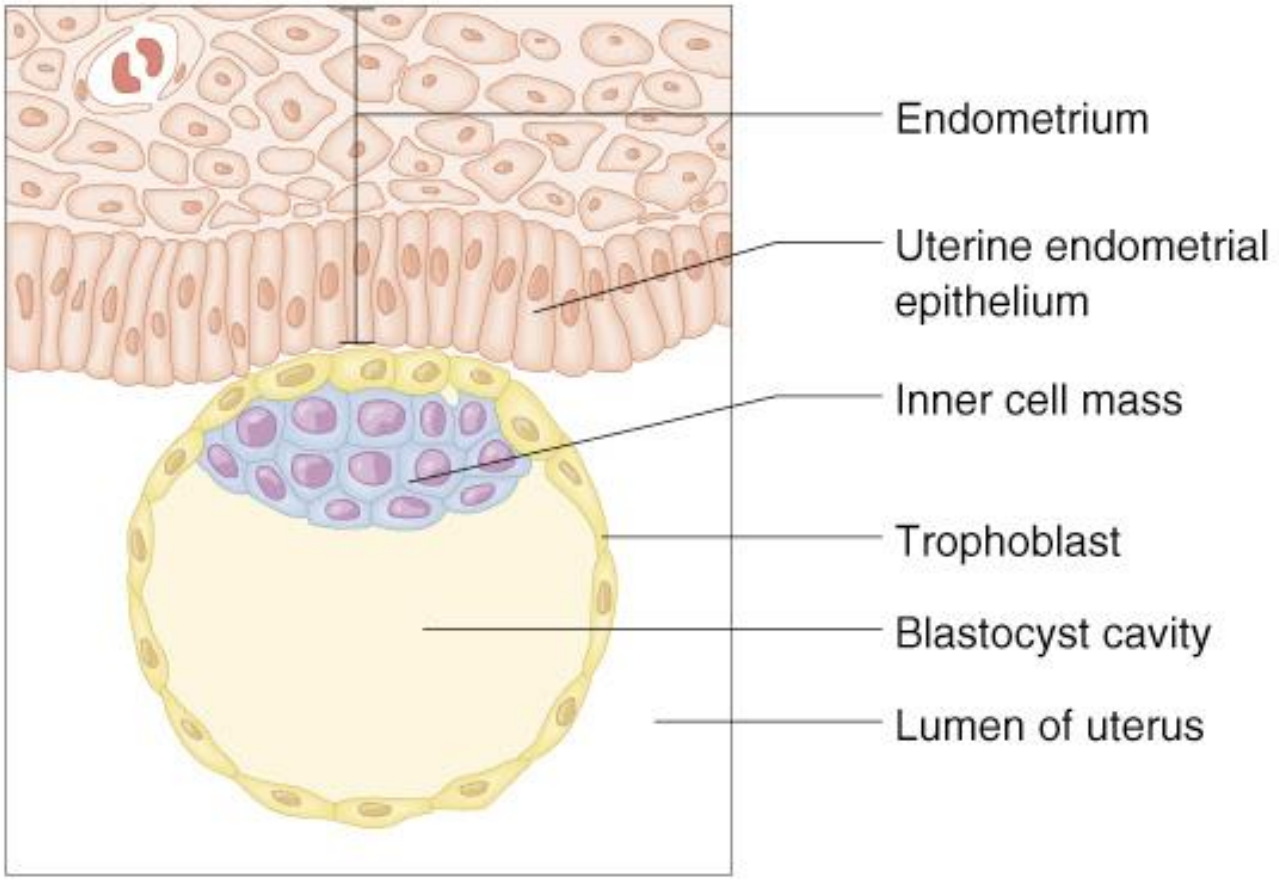


Figure 29.5a

Implantation

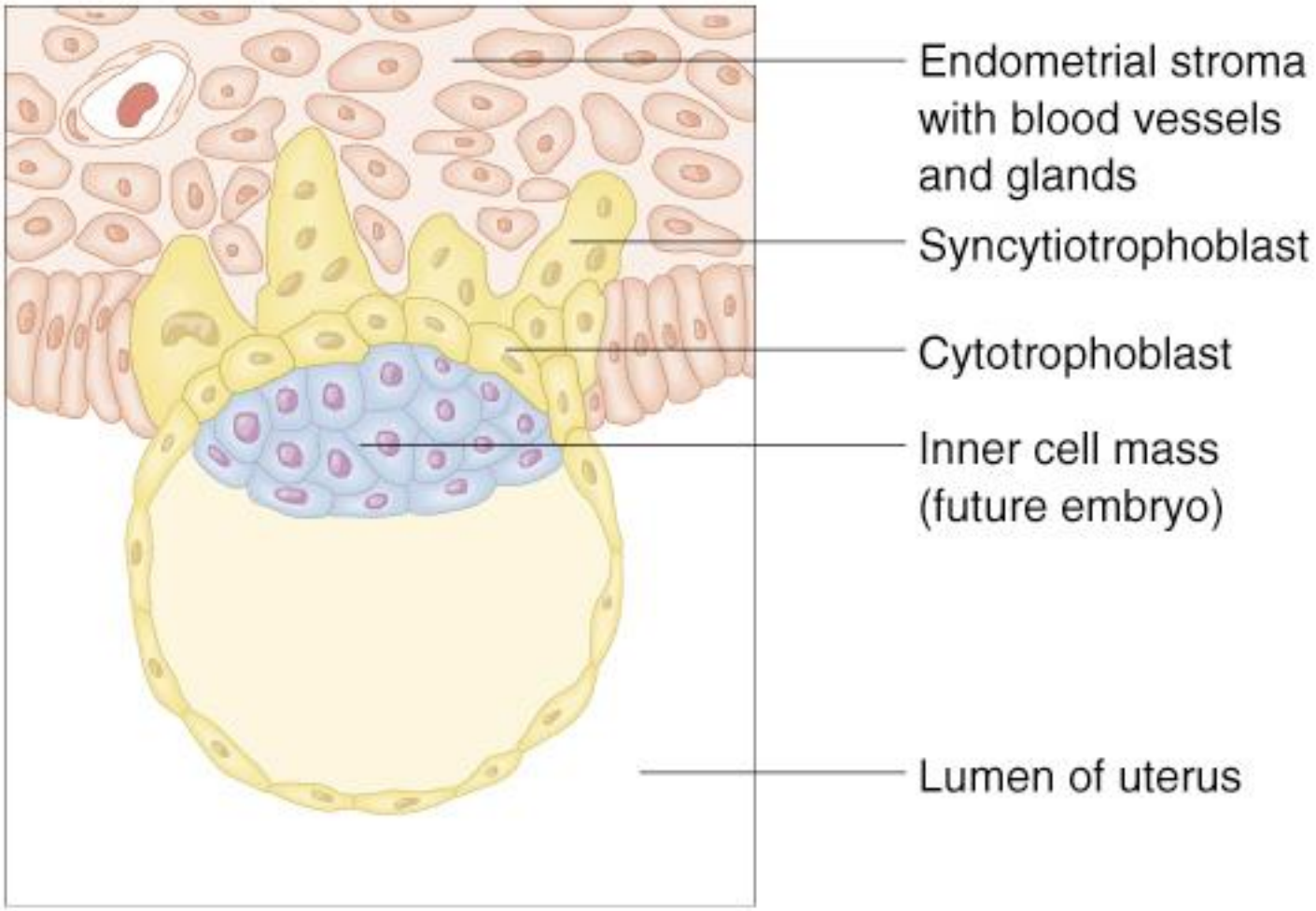


Figure 29.5b

Implantation

- Viability of the corpus luteum is maintained by human chorionic gonadotropin (hCG) secreted by the trophoblasts
- hCG prompts the corpus luteum to continue to secrete progesterone and estrogen
- Chorion – developed from trophoblasts after implantation, continues this hormonal stimulus
- Between the second and third month, the placenta:
  - Assumes the role of progesterone and estrogen production
  - Is providing nutrients and removing wastes

Placentation

- Formation of the placenta from:
  - Embryonic trophoblastic tissues
  - Maternal endometrial tissues
- The chorion develops fingerlike villi, which:
  - Become vascularized
  - Extend to the embryo as umbilical arteries and veins
  - Lie immersed in maternal blood
- Decidua basalis – part of the endometrium that lies between the chorionic villi and the stratum basalis

Placentation

- Decidua capsularis – part of the endometrium surrounding the uterine cavity face of the implanted embryo
- The placenta is fully formed and functional by the end of the third month
- Embryonic placental barriers include:
  - The chorionic villi
  - The endothelium of embryonic capillaries
- The placenta also secretes other hormones – human placental lactogen, human chorionic thyrotropin, and relaxin

Placentation

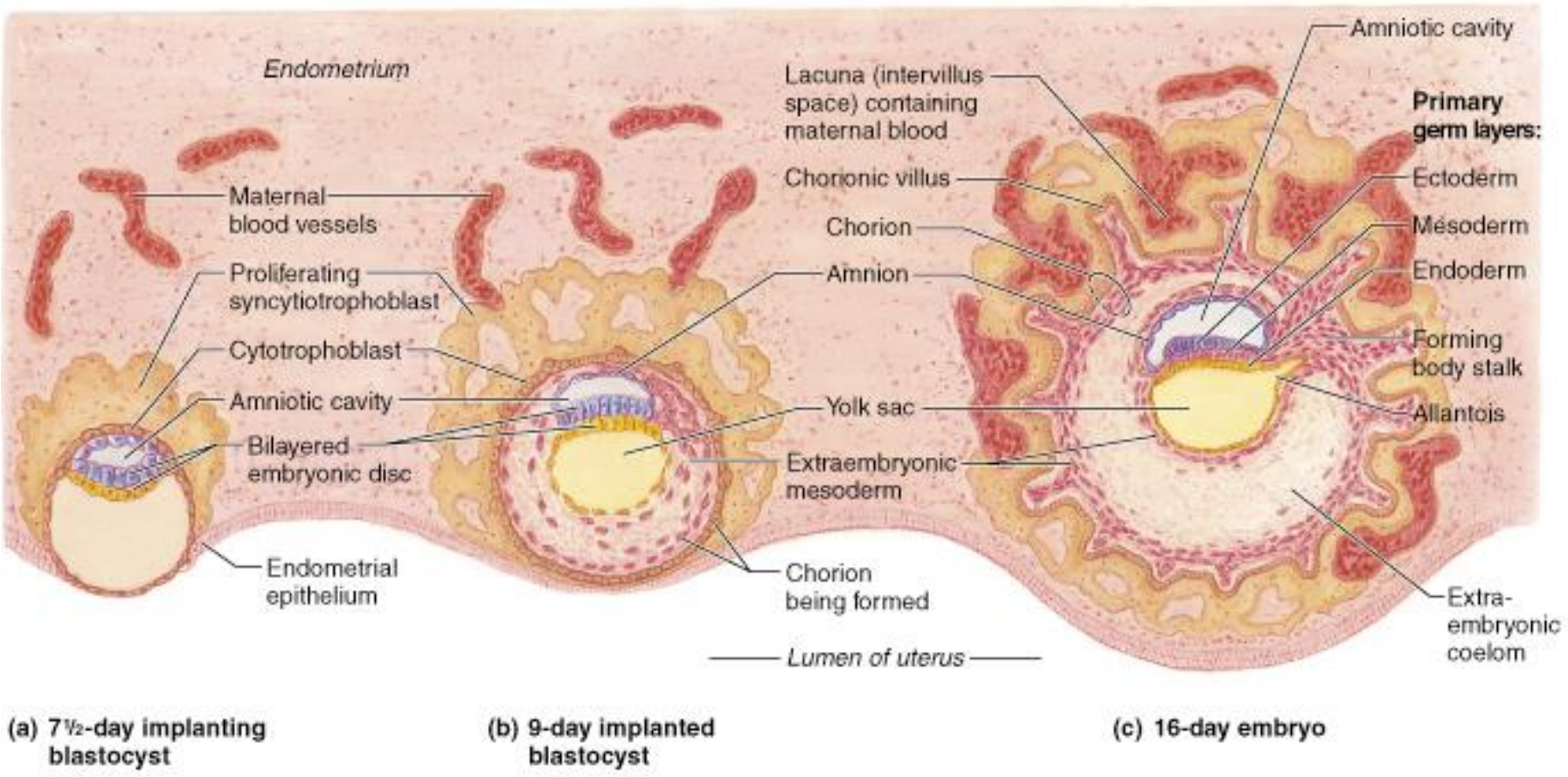


Figure 29.7a-c

Placenta

Fetus and placenta - uniform metabolic and hormone system

Nutritional function and elimination of metabolism products

Input of O2, nutrients, water, ions, vitamines for the fetus

Output of CO2, urea, uric acid

Glycogen synthesis

Intervillous area - contact maternal and fetal blood

Implantation

Fetus and mother - two genetically distinct individuals

Fetus - transplant of foreign tissue in mother

tolerance, no rejection

placental trophoblast separating maternal and fetal tissue does not express class I and II MHC genes, express non-polymorphic HLA-G

low maternal Abs production during pregnancy

Placenta - Endocrine function

Early pregnancy
Corpus luteum - critical role first 6 weeks (ovariectomy at early stage _abortion); secretes estrogens, progesterone, relaxin (inhibits myometrial contractions); function decline after 8th week, however low concentrataions persists throughout pregnancy

Placenta takes over the function after 8th week
produces estrogen, progesterone,
hCG (human chorionic gonadotropin),
hCS (human chorionic somatomammotropin),
relaxin (inhibiting myometrial contractions), prolactin,
GnRH (gonadotropin-releasing hormone) and
inhibin)

hCG

GP, Alpha and Beta subunits

- Alpha subunit identical to LH, FSH, TSH

6.-14. day after conception- detected in blood, urine

Produced by placenta - syncytiotrophoblast, fetal liver and kidney

Acts on the same receptor as LH – secretion of progesterone, estrogen in corpus luteum and later in placenta .

Tumor marker - secreted by GIT tumors

hCS -Human Chorionic Somatomammotropin

Secreted by syncytiotrophoblast
Stimulates the maturation of the breasts
Maternal growth hormone of pregnancy

The amount of hCS secreted is proportionate to the size of placenta (normally 1/6 weight of fetus)

Low hCS levels a sign of placental insufficiency

Nitrogen , K, Ca retention; lipolysis, decrease of glucose utilization (diversion of glucose to the fetus)

Implantation

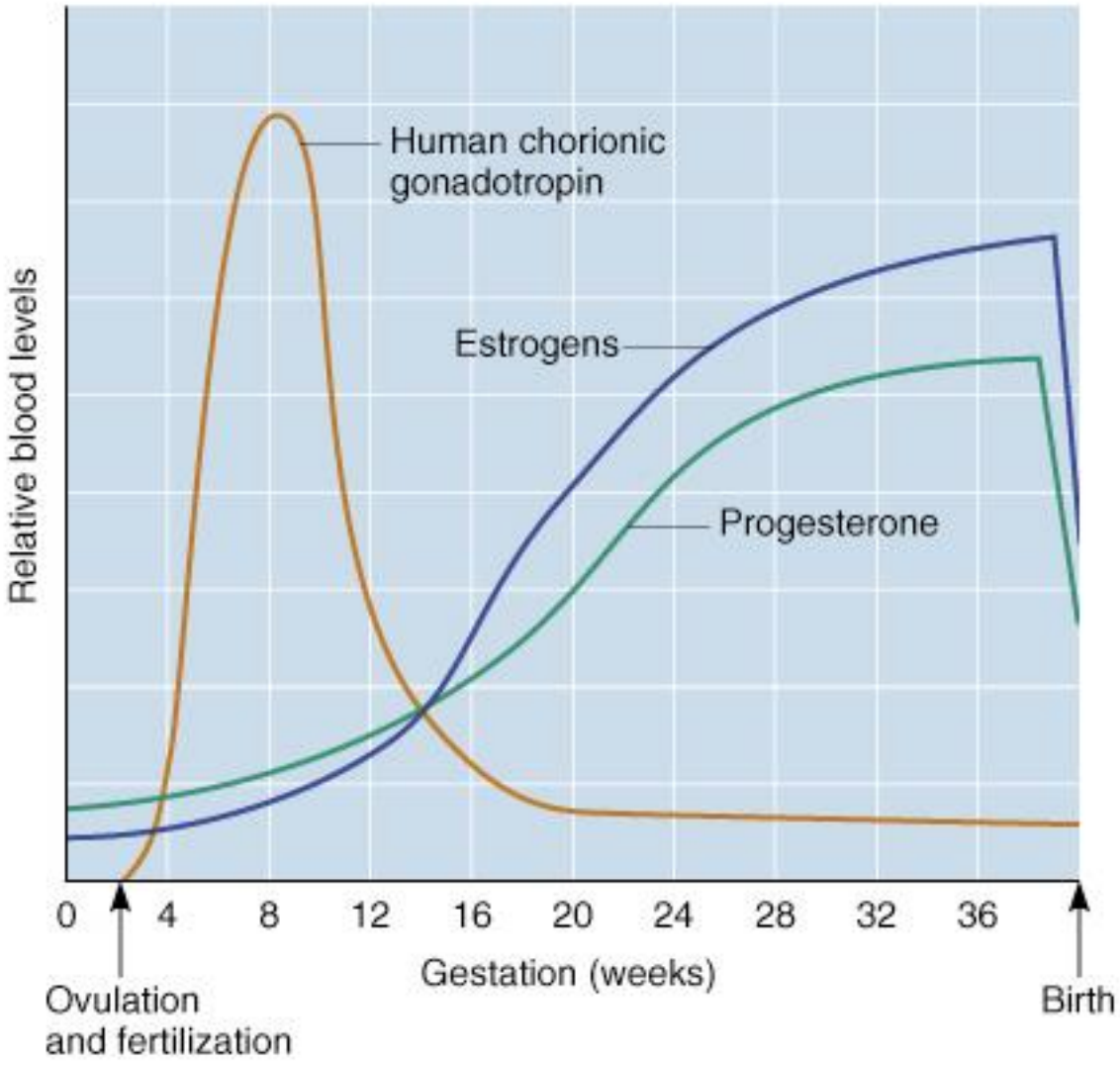


Figure 29.6

Fetoplacental unit

Fetus and placenta interact in formation of steroid hormones

Urinary estriol excretion of the mother monitored as an index of the state of fetus vitality

Secretion of estrogens during pregnancy, peak before delivery, after delivery it decreases .

DHEAS - dehydroepiandrosterone sulphate
16-0HDHEAS - 16-hydroxydehydroepiandrosterone sulphate

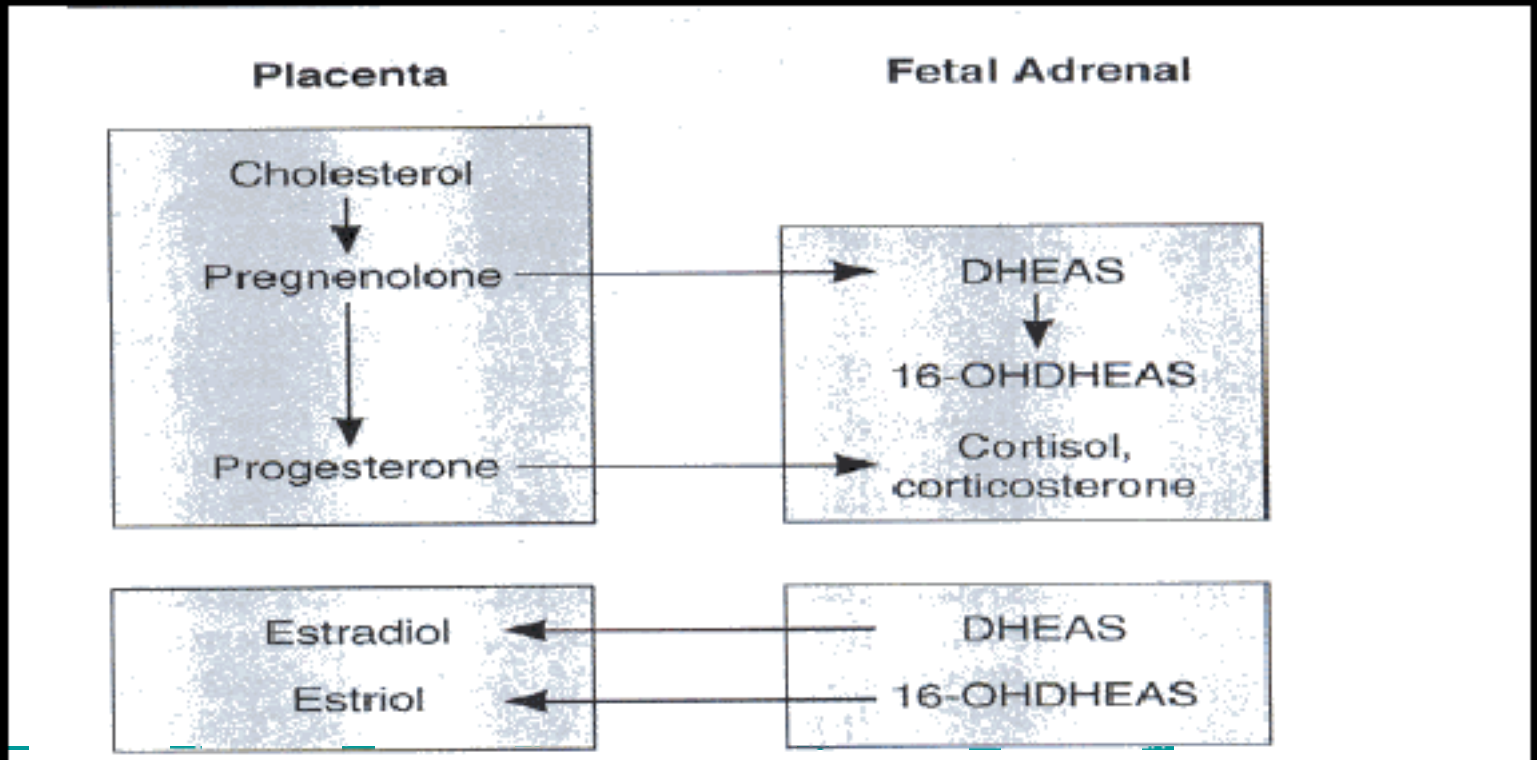


Figure 23–38. Interactions between the placenta and the fetal adrenal cortex in the production of steroids.

Development of Fetal Circulation

- By the end of the 3rd week:
  - The embryo has a system of paired vessels
  - The vessels forming the heart have fused
- Unique vascular modifications seen in prenatal development include umbilical arteries and veins, and three vascular shunts (occluded at birth)
  - Ductus venosus – venous shunt that bypasses the liver
  - Foramen ovale – opening in the interatrial septa to bypass pulmonary circulation
  - Ductus arteriosus – transfers blood from the right ventricle to the aorta

Development of Fetal Circulation

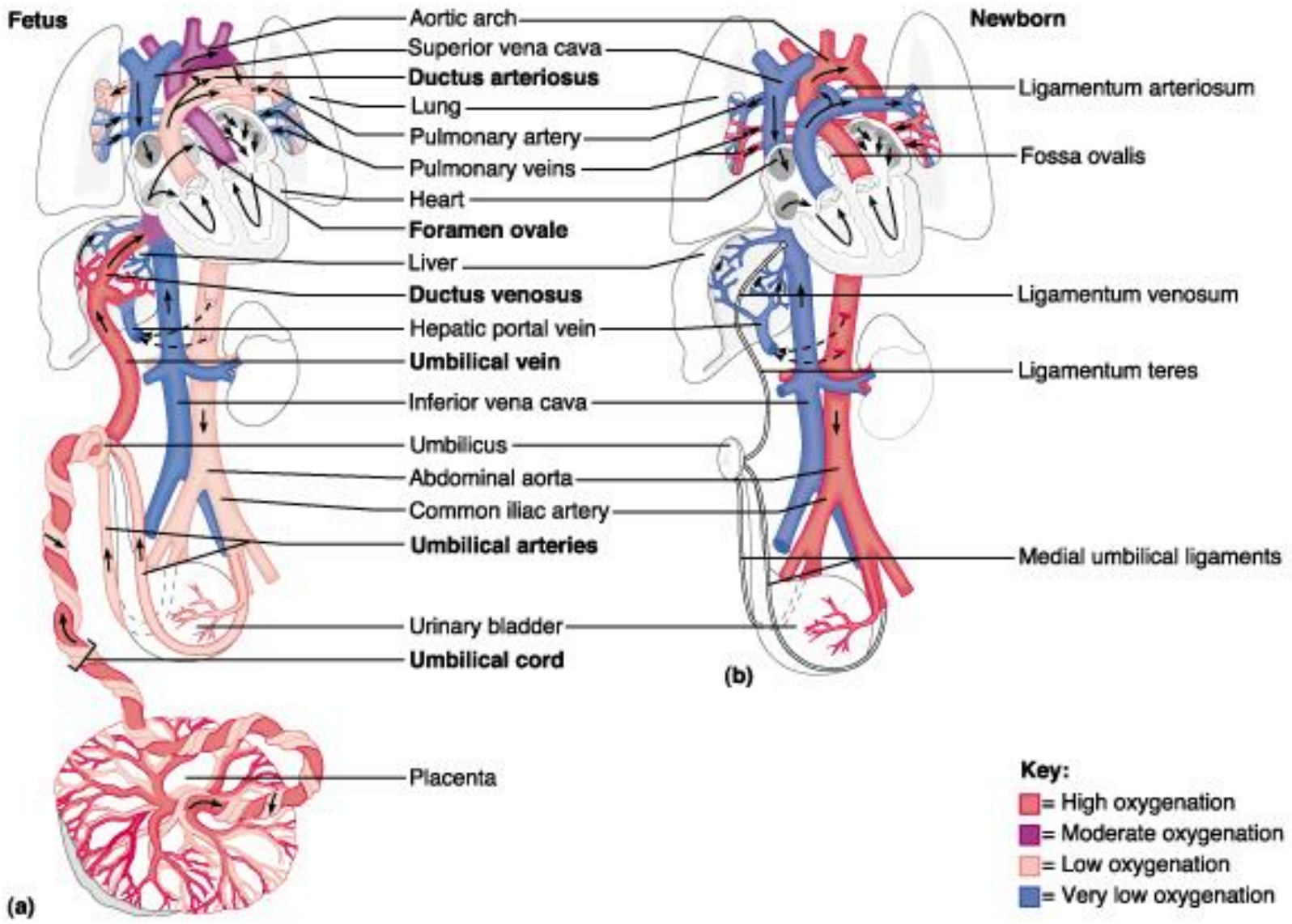
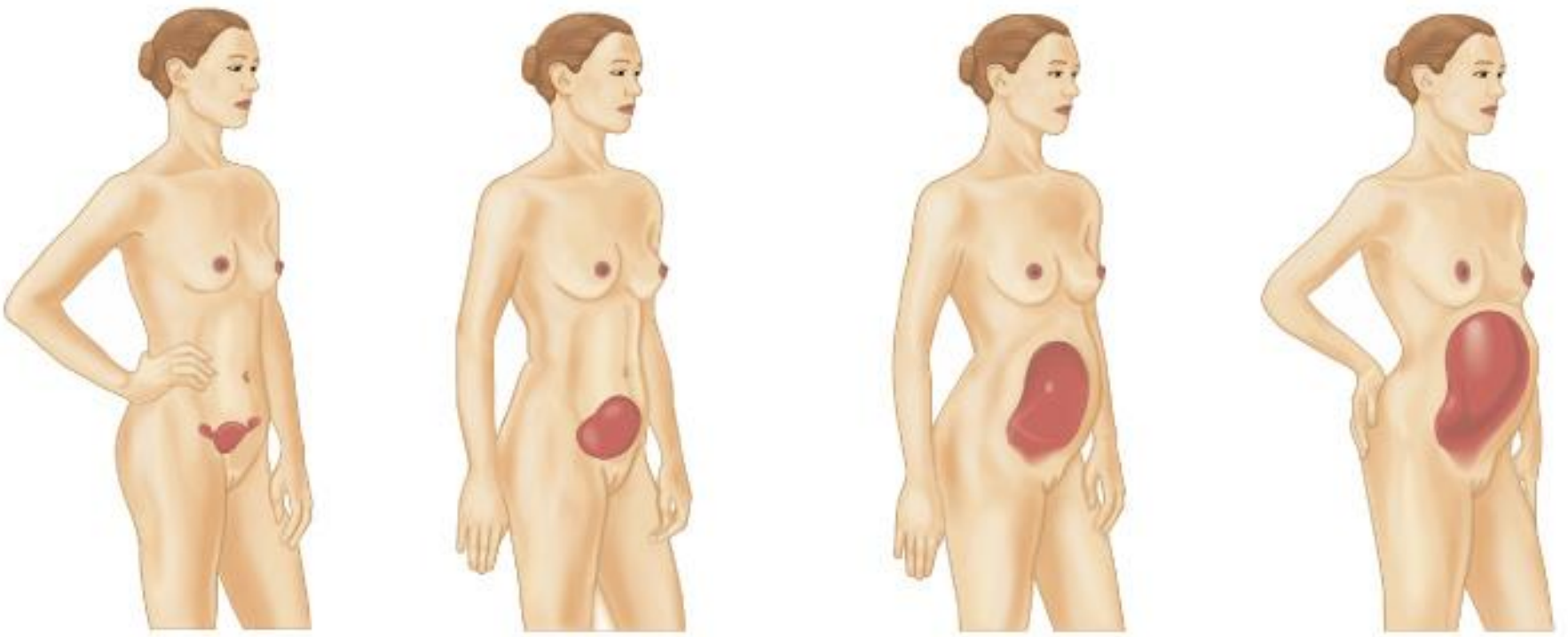


Figure 29.13

Effects of Pregnancy: Anatomical Changes

- Chadwick's sign – the vagina develops a purplish hue
- Breasts enlarge and their areolae darken
- The uterus expands, occupying most of the abdominal cavity
- Lordosis is common due to the change of the body's center of gravity
- Relaxin causes pelvic ligaments and the pubic symphysis to relax
- Typical weight gain is about 29 pounds

Effects of Pregnancy: Anatomical Changes



(a) Before conception (b) 4 months (c) 7 months (d) 9 months

Figure 29.15

Effects of Pregnancy: Metabolic Changes

- The placenta secretes human placental lactogen (hPL), also called human chorionic somatomammotropin (hCS),
- hPL promotes growth of the fetus and exerts a maternal glucose-sparing effect
- Human chorionic thyrotropin (hCT) increases maternal metabolism
- Parathyroid hormone levels are high, ensuring a positive calcium balance

Effects of Pregnancy: Physiological Changes

- GI tract – morning sickness occurs due to elevated levels of estrogen and progesterone
- Urinary tract – urine production increases to handle the additional fetal wastes
  - Respiratory – edematous and nasal congestion may occur
- Dyspnea (difficult breathing) may develop late in pregnancy
- Cardiovascular system – blood volume increases 25-40%
  - Venous pressure from lower limbs is impaired, resulting in varicose veins

Parturition: Initiation of Labor

- 270 days after fertilization, 284 days from 1st day of MC
- Last month of pregnancy - Irregular uterine contractions that increases in frequency , cervix softens and dilates, uterus contracts and expels fetus, dilatation sets up signals in afferent nerves to cause oxytocin secretion
- Increase in estrogen secretion at last weeks of pregnancy :
- 1) Increase in number of oxytocin receptors and causes formation of Prostaglandins..
- 2) Causes Myometrial weakness and irritability.
- As birth nears, oxytocin and prostaglandins cause uterine contractions

Parturition:

Emotional and physical stress:

Activates the hypothalamus

Sets up a positive feedback mechanism, releasing more oxytocin

Major hormone inducing uterine contractions oxytocin

1. Acts on uterine smooth muscle cells to contract them

2. Stimulate formation of prostaglandins in the decidua .
(endometrium of pregnancy) that enhance oxytocin-induced contractions

spinal reflexes and voluntary contractions of abdominal muscles
aid in delivery

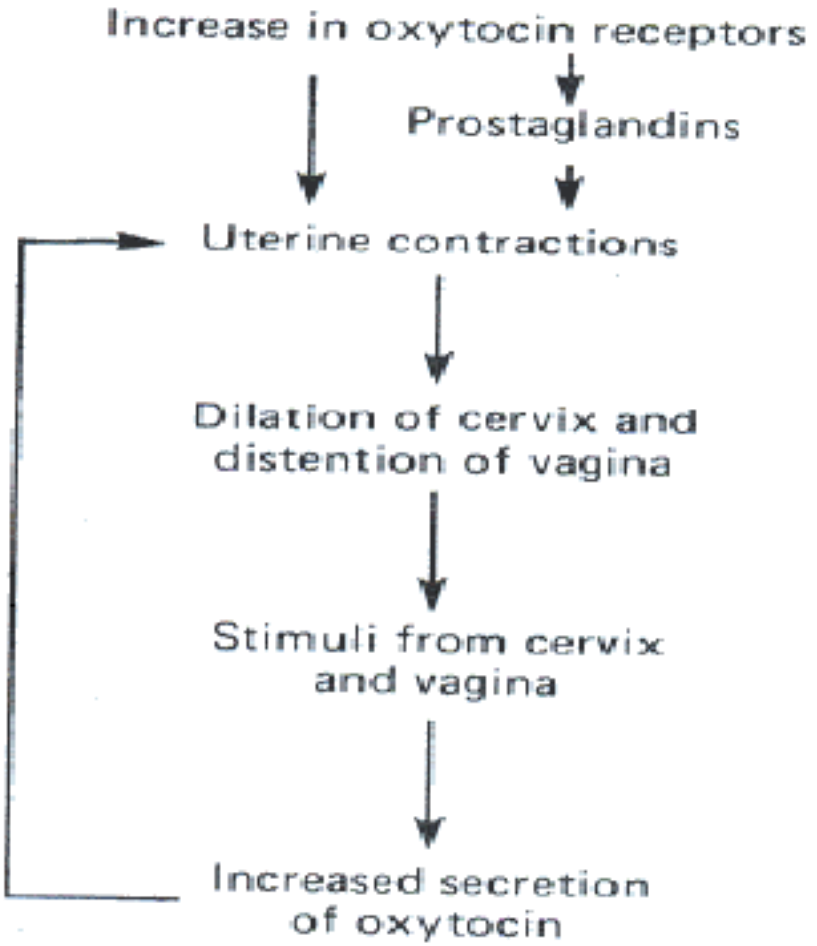


Figure 23–39. Role of oxytocin in parturition.

Parturition: Initiation of Labor

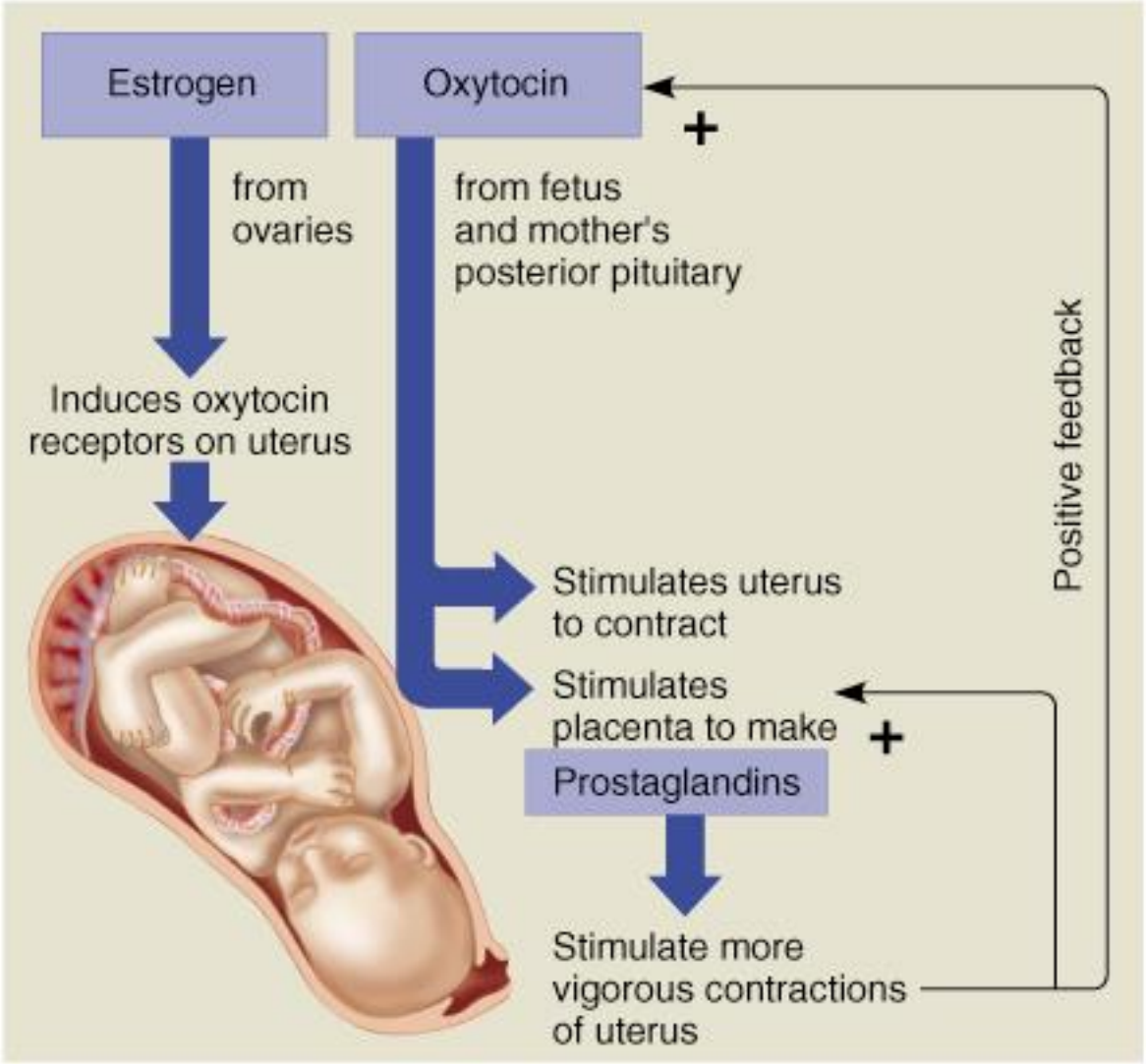


Figure 29.16

Role of fetus in triggering onset of labor

- Increase in fetal plasma glucocorticoid concentration may be involved in initiation of labor

Stages of Labor: Dilation Stage

- From the onset of labor until the cervix is fully dilated (10 cm)
- Initial contractions are 15–30 minutes apart and 10–30 seconds in duration
- The cervix effaces and dilates
- The amnion ruptures, releasing amniotic fluid (breaking of the water)
- Engagement occurs as the infant’s head enters the true pelvis

Stages of Labor: Dilation Stage

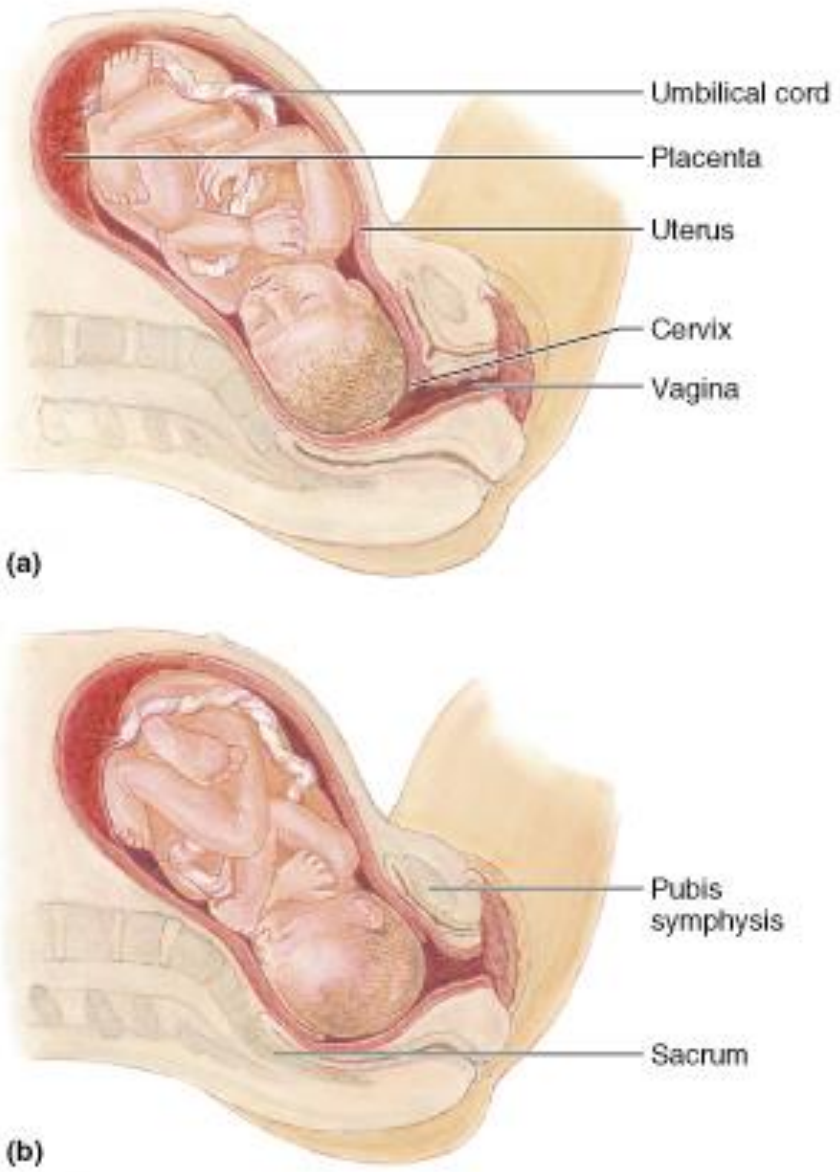


Figure 29.17a, b

Stages of Labor: Expulsion Stage

- From full dilation to delivery of the infant
- Strong contractions occur every 2–3 minutes and last about 1 minute
- The urge to push increases in labor without local anesthesia
- Crowning occurs when the largest dimension of the head is distending the vulva

Figure 29.17c

Stages of Labor: Placental Stage

- The delivery of the placenta is accomplished within 30 minutes of birth
- Afterbirth – the placenta and its attached fetal membranes
- All placenta fragments must be removed to prevent postpartum bleeding

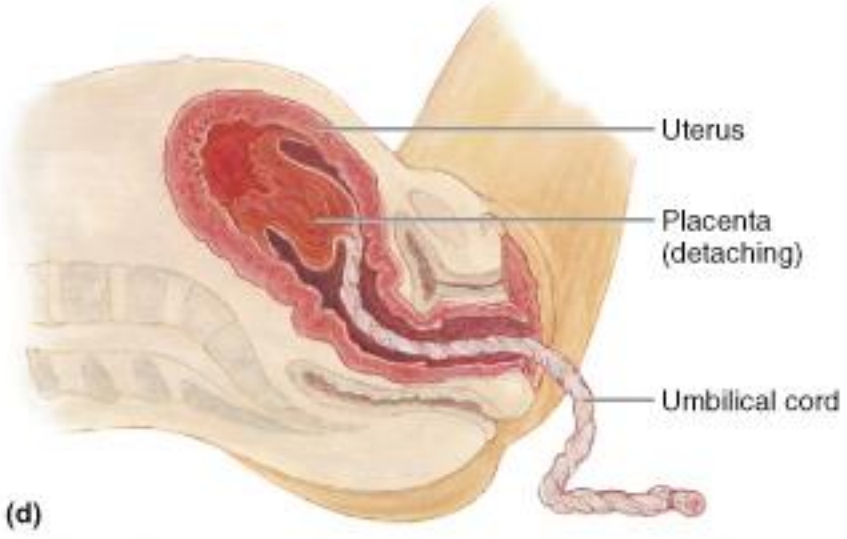


Figure 29.17d

Extrauterine Life

- At 1-5 minutes after birth, the infant's physical status is assessed based on five signs: heart rate, respiration, color, muscle tone, and reflexes
- Each observation is given a score of 0 to 2
- Apgar score – the total score of the above assessments
  - 8-10 indicates a healthy baby
  - Lower scores reveal problems

First Breath

- Once carbon dioxide is no longer removed by the placenta, central acidosis occurs
- This excites the respiratory centers to trigger the first inspiration
- This requires tremendous effort – airways are tiny and the lungs are collapsed
- Once the lungs inflate, surfactant in alveolar fluid helps reduce surface tension

Occlusion of Fetal Blood Vessels

- Umbilical arteries and vein constrict and become fibrosed
- Fates of fetal vessels
  - Proximal umbilical arteries become superior vesical arteries and distal parts become the medial umbilical ligaments
  - The umbilical vein becomes the ligamentum teres
  - The ductus venosus becomes the ligamentum venosum
  - The foramen ovale becomes the fossa ovalis
  - The ductus arteriosus becomes the ligamentum arteriosum

Transitional Period

- Unstable period lasting 6-8 hours after birth
- The first 30 minutes the baby is alert and active
  - Heart rate increases (120-160)
  - Respiration is rapid and irregular
  - Temperature falls
- Activity then diminishes and the infant sleeps about three hours
- A second active stage follows in which the baby regurgitates mucus and debris
- After this, the infant sleeps, with waking periods occurring every 3-4 hours

Lactation

- The production of milk by the mammary glands
- Estrogens - Proliferation of mammary ducts
  Progesterone -Development of lobules
- During pregnancy, prolactin levels increases steadily until term ,and under the influence of this hormone plus the high levels of Estrogens & Progesterone causes the full lobuloalveolar development of breasts.
- After delivery ,increased levels of prolactin and a decline in estrogens and progesterone bring about copious milk secretion and in the presence of oxytocin ,ejection of milk .

Lactation

- After birth, milk production is stimulated by the sucking infant

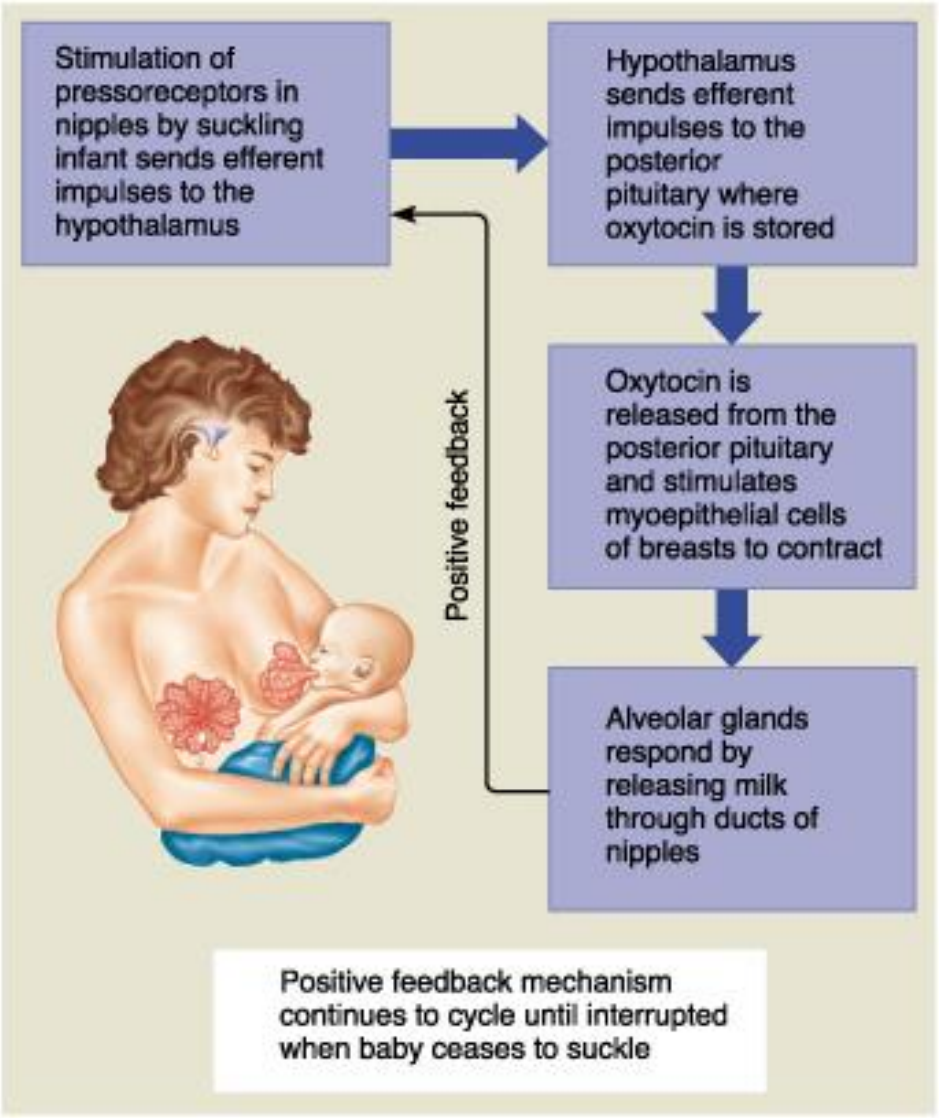


Figure 29.18

Breast Milk

- Advantages for the infant include:
  - Fats and iron are better absorbed
  - Its amino acids are metabolized more efficiently than those of cow's milk
  - Beneficial chemicals are present – IgA, other immunoglobulins, complement, lysozyme, interferon, and lactoperoxidase
  - Interleukins and prostaglandins are present, which prevent overzealous inflammatory responses
  - Its natural laxatives help cleanse the bowels of meconium

Effect of Lactation on MC

•Not nursing females – Menstrual cycle appears at 6 weeks after delivery when secretion of gonadotropins re-starts

•Nursing females - Amenorrhea 25-30weeks

Nursing stimulates Prolactin secretion, and there is evidence the Prolactin inhibits GnRH secretion .

No pituitary gonadotropins : No effect on ovary ,as a results inhibition of ovulation and ovaries become inactive .