

Third Month to Birth



The Fetus & Placenta

Development Of The Fetus



Fetal period

- 9th week to birth
- tissues & organs amaturation
- rapid growth of the body
- **crown rump length (CRL)** (sitting height)
- **crown-heel length (CHL)** (standing height)
- Growth in length third, 4th , 5th
- increase in during the last 2 months of gestation

pregnancy length;

- **280 days, or 40 weeks after LNMP**
- **266 days or 38 weeks after fertilization**

TABLE 8.1 Growth in Length and Weight During the Fetal Period

| Age (Wk) | CRL (cm) | Weight (g) |
|----------|----------|-------------|
| 9–12 | 5–8 | 10–45 |
| 13–16 | 9–14 | 60–200 |
| 17–20 | 15–19 | 250–450 |
| 21–24 | 20–23 | 500–820 |
| 25–28 | 24–27 | 900–1,300 |
| 29–32 | 28–30 | 1,400–2,100 |
| 33–36 | 31–34 | 2,200–2,900 |
| 37–38 | 35–36 | 3,000–3,400 |

Monthly Changes

Head growth slowdown

- third month beginning, the head half of the CRL
- 5th month beginning the head about 1/3 of the CHL
- at birth, head head about 1/4 of the CHL



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| 33–36 | 31–34 | 2,200–2,900 |
| 37–38 | 35–36 | 3,000–3,400 |



Monthly Changes



third month, the face becomes more human looking (Figs. 8.3 and 8.4). The

- Eyes
- Ears
- The limbs length

the 12th week.

- **Primary ossification centers** (long bones & skull)
- external genitalia development (ultrasound)
- **intestinal loops have** withdrawn into the abdominal cavity
- muscular activity.

During the **4th & 5th months**, the fetus lengthens rapidly

- CRL at end of first half of intrauterine life, 15 cm
- end of the 5th month 500 g weight
- **lanugo hair; eyebrows**
- **During the 5th month, fetus movements felt by mother**
- **weight increases** during the last 2.5 months,



Figure 8.4 A 12-week fetus in utero. Note the extremely thin skin and underlying blood vessels. The face has all of the human characteristics, but the ears are still primitive. Movements begin at this time but are usually not felt by the mother.

Monthly Changes

During the sixth month

- reddish & wrinkled fetus skin, lack of underlying connective tissue
- the respiratory system & CNS have not differentiated sufficiently

During the last 2 months

- fetus obtains well-rounded contours
- Deposition of subcutaneous fat

vernix caseosa

- sebaceous glands secretory products

end of the ninth month

- the skull (largest circumference of the body)

At the time of birth
normal fetus

- weight 3,000 to 3,400 gr
- CRL is about 36 cm
- CHL is about 50 cm
- Pronounced Sexual characteristics and the testes should be in the scrotum.

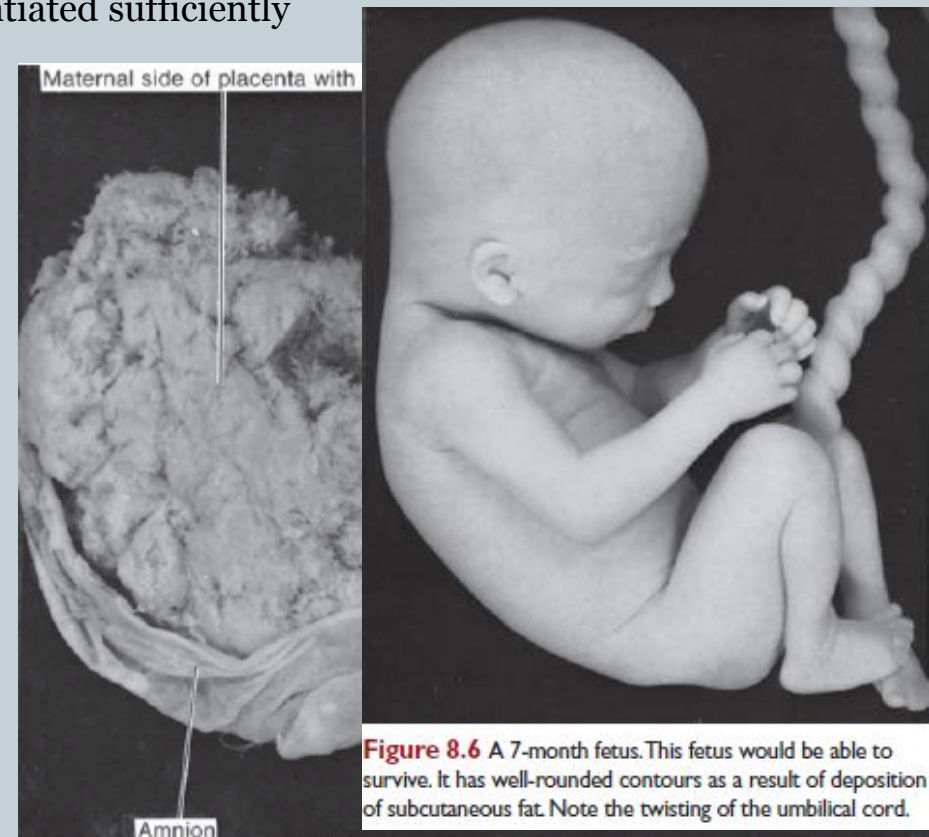


Figure 8.6 A 7-month fetus. This fetus would be able to survive. It has well-rounded contours as a result of deposition of subcutaneous fat. Note the twisting of the umbilical cord.

TABLE 8.2 *Developmental Horizons During Fetal Life Event*

| | Age (Wk) |
|--|----------|
| Taste buds appear | 7 |
| Swallowing | 10 |
| Respiratory movements | 14–16 |
| Sucking movements | 24 |
| Some sounds can be heard | 24–26 |
| Eyes sensitive to light ^a | 28 |
| ^a Recognition of form and color occurs postnatally. | |

Time of Birth



- 266 days, or 38 weeks, after fertilization
- Fertilization, 12 hours of ovulation
- Sperm can survive up to 6 days in female tract
- 280 days or 40 weeks from the first day of the LNMP
- bleeding about 14 days after fertilization
- Most fetuses are born within 10 to 14 days
- **premature;**
- **postmature.**

during the 7th to 14th weeks

- **ultrasound** (1 to 2 days) CRL measurement

16th to 30th weeks are

- **biparietal diameter (BPD)**
- **Head** circumference
- **Abdominal** circumference
- femur length

Clinical Correlates

Low Birth Weight

There is considerable variation in fetal length and weight, and sometimes these values do not correspond with the calculated age of the fetus in months or weeks. Most factors influencing length and weight are genetically determined, but environmental factors also play an important role.

The average size of a newborn is 2,500 to 4,000 g (6 to 9 lb) with a length of 51 cm (20 in). The term **low birth weight (LBW)** refers to a weight <2,500 g, regardless of gestational age. Many infants weigh <2,500 g because they are **preterm** (born before 37 weeks of gestation). In contrast, the terms **intrauterine growth restriction (IUGR)** and **small for gestational age (SGA)** take into account gestational age.

IUGR is a term applied to infants who do not attain their optimal intrauterine growth. These infants are pathologically small and at risk for poor outcomes. Infants who are **SGA** have a birth weight that is below the 10th percentile for their gestational age. These babies may be pathologically small (they may have IUGR) or they may be constitutionally small (healthy, but smaller in size). The challenge is to differentiate the two conditions so that healthy, but small babies are not subjected to high-risk protocols used for babies with IUGR.

Approximately 1 in 10 babies have IUGR and therefore have an increased risk of neurological problems, congenital malformations, meconium aspiration, hypoglycemia, hypocalcemia, and respiratory distress syndrome (RDS). There are also long-term effects on these infants. For

example, babies with IUGR have been shown to have a greater chance as adults to develop a metabolic disorder later in life, such as obesity, hypertension, hypercholesterolemia, cardiovascular disease, and type 2 diabetes (called **Barker's hypothesis**).

The incidence of IUGR is higher in blacks than in whites. Causative factors include chromosomal abnormalities; teratogens; congenital infections (rubella, cytomegalovirus, toxoplasmosis, and syphilis); poor maternal health (hypertension and renal and cardiac disease); the mother's nutritional status and socioeconomic level; her use of cigarettes, alcohol, and other drugs; placental insufficiency; and multiple births (e.g., twins, triplets).

The major growth-promoting factor during development before and after birth is **insulin-like growth factor-I (IGF-I)**, which has **mitogenic and anabolic effects**. Fetal tissues express IGF-I, and serum levels are correlated with fetal growth. Mutations in the *IGF-I* gene result in IUGR, and this growth retardation is continued after birth. In contrast to the prenatal period, postnatal growth depends on **growth hormone (GH)**. This hormone binds to its receptor (GHR), activating a signal transduction pathway and resulting in synthesis and secretion of IGF-I. Mutations in the GHR result in **Laron's dwarfism**, which is characterized by marked short stature, and sometimes blue sclera. These individuals show little or no IUGR, because IGF-I production does not depend on GH during fetal development.



Fetal membrane & placenta



Placenta

- Facilitate nutrients & gas exchange

Beginning of 9th week

- Major changes
- Increase in surface area between fetus & mother

Fetal membrane

- Increase in amniotic fluid production

Change in the trophoblast

fetal part of Placenta

- Trophoblast
- Extraembryonic mesoderm (chorionic plate)

Maternal part of Placenta

- Uterus endometrium

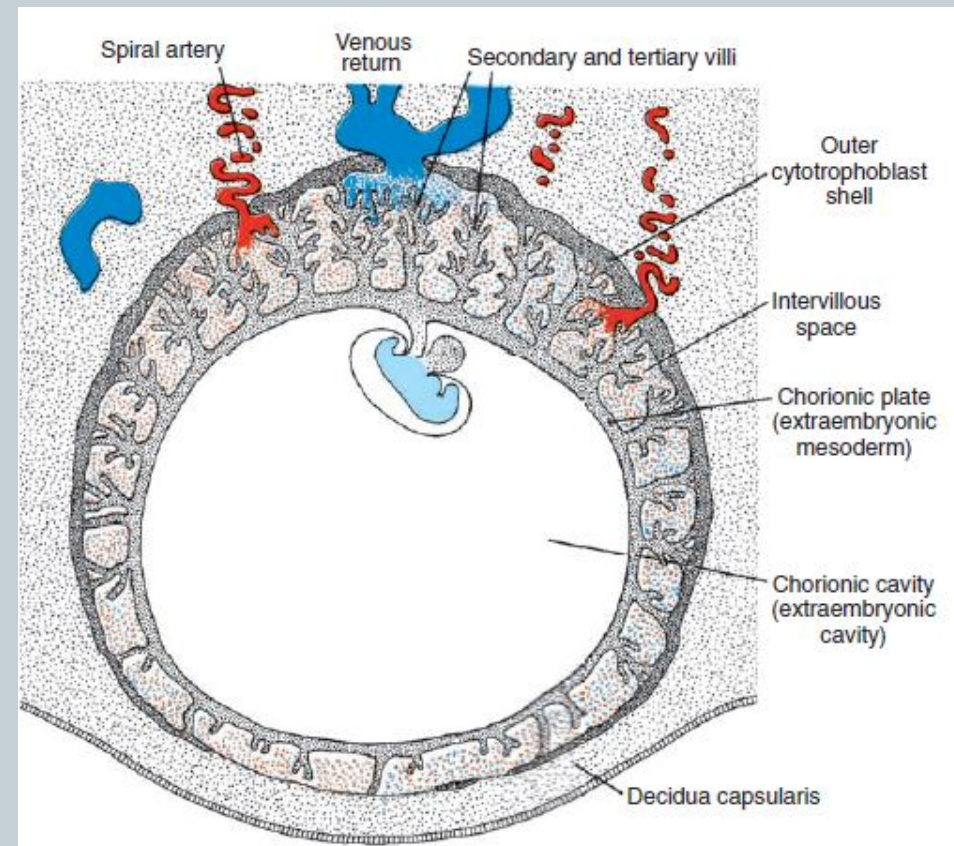
Beginning of second month

- secondary & tertiary villi
- (radial appearance)

Cytotrophoblast invasion to maternal endothelium

Epithelium to endothelium

Free villi formation



Change in the trophoblast

- **Beginning of 4th month**
- **Cytotrophoblast**
- **Mesoderm (connective tissue)**
- **Syncytium**
- **Endothelium**

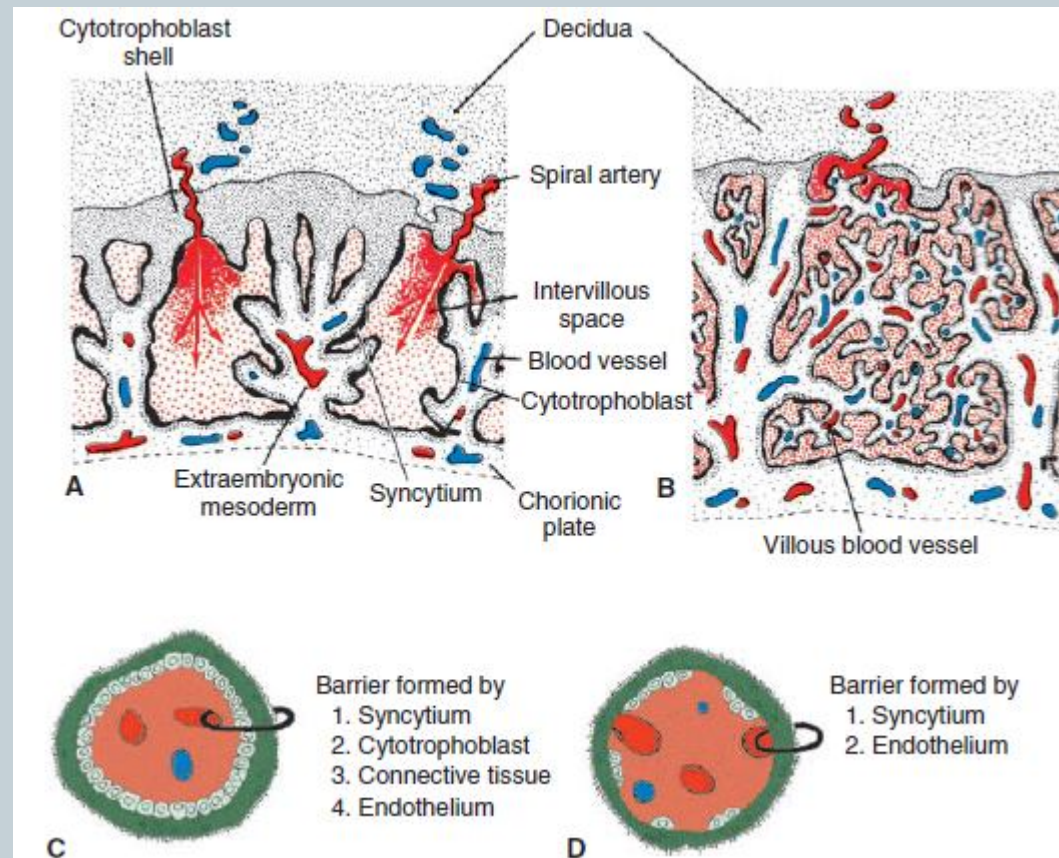


Figure 8.8 Structure of villi at various stages of development. **A.** During the fourth week. The extraembryonic mesoderm penetrates the stem villi in the direction of the decidual plate. **B.** During the fourth month. In many small villi, the wall of the capillaries is in direct contact with the syncytium. **C, D.** Enlargement of the villus as shown in Figures 8.8A, B.

Clinical Correlates



Preeclampsia is a condition characterized by maternal hypertension and proteinuria due to reduced organ perfusion and occurs in approximately 5% of pregnancies. The condition may progress to eclampsia, which is characterized by seizures. Preeclampsia begins suddenly anytime from approximately 20 weeks' gestation to term and may result in fetal growth retardation, fetal death, or death of the mother. In fact, preeclampsia is a leading cause of maternal mortality in the United States and is completely reversible by delivery of the baby. However, delivery too early puts the infant at risk for complications related to preterm birth. Despite many years of research, the cause of preeclampsia is unknown. The condition

appears to be a trophoblastic disorder related to failed or incomplete differentiation of cytotrophoblast cells, many of which do not undergo their normal epithelial-to-endothelial transformation. As a result, invasion of maternal blood vessels by these cells is rudimentary. How these cellular abnormalities lead to hypertension and other problems is not clear. Risk factors for preeclampsia include, preeclampsia in a previous pregnancy, nulliparity (first pregnancy), obesity, family history of preeclampsia, multiple gestation (twins or more), and medical conditions, such as hypertension and diabetes. Preeclampsia also commonly occurs in women with hydatidiform moles (see Chapter 4, p. 48) in which case it occurs early in pregnancy.

Chorion frondosum & decidua basalis

Embryonic pole

- Chorion frondosum

Abembryonic pole

- Chorion laeve

Decidua

- Decidua basalis
- Decidua capsularis
- Decidua parietalis

Amniochorionic membrane

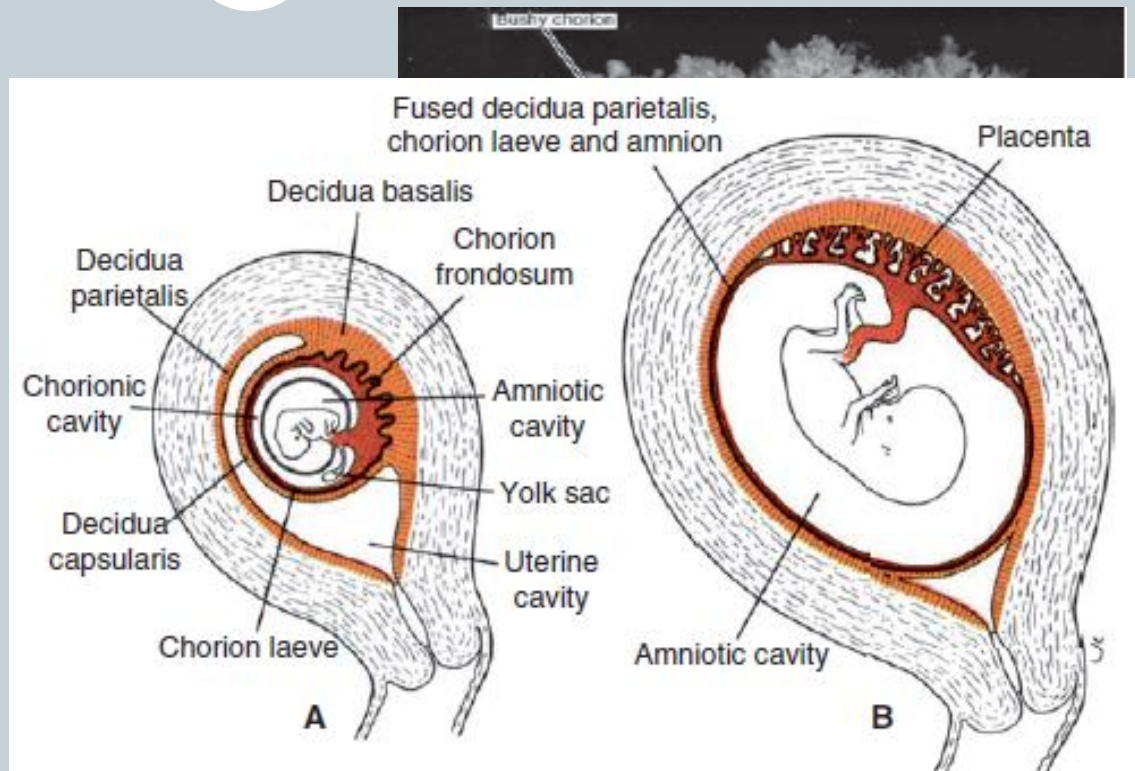


Figure 8.10 Relation of fetal membranes to wall of the uterus. **A.** End of the second month. Note the yolk sac in the chorionic cavity between the amnion and chorion. At the abembryonic pole, villi have disappeared (chorion laeve). **B.** End of the third month. The amnion and chorion have fused, and the uterine cavity is obliterated by fusion of the chorion laeve and the decidua parietalis.

showing the bushy appearance of the trophoblast at the embryonic pole in contrast to small villi at the abembryonic pole. Note the connecting stalk and yolk sac with its extremely long vitelline duct.

Structure of the placenta

beginning of 4th month

Placenta:

- (1) **fetal portion** (chorion frondosum)
- (2) **maternal portion** (decidua basalis)

4th & 5th month

Decidual septa

Cotyledons

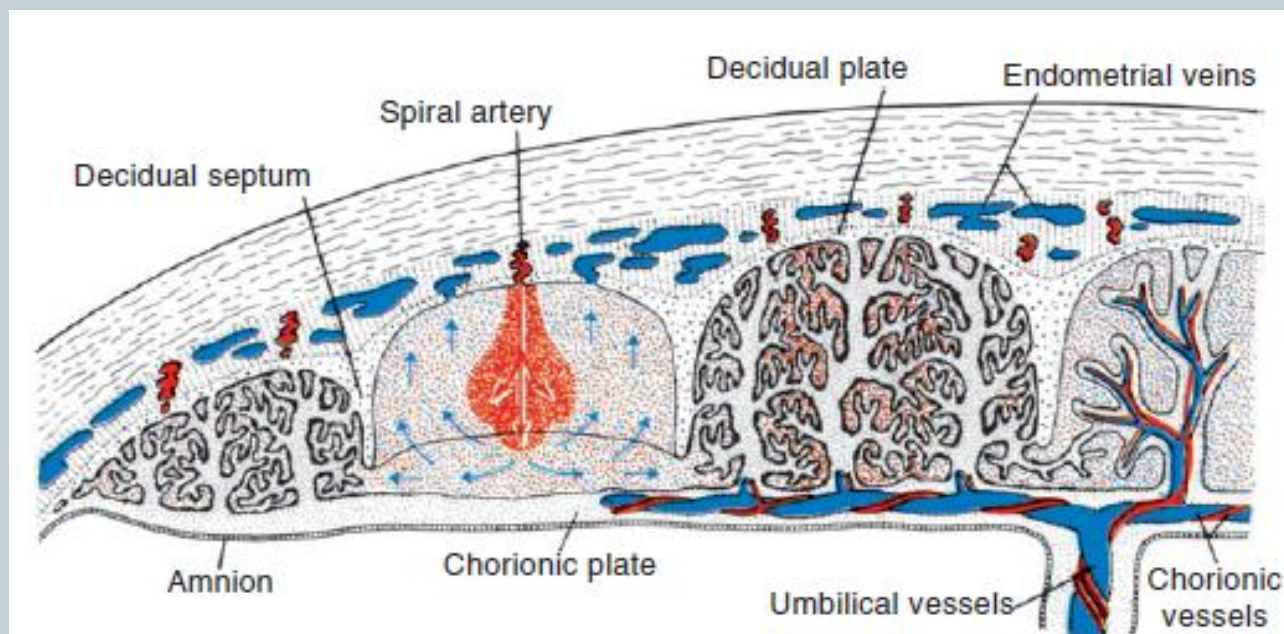


Figure 8.13 The placenta in the second half of pregnancy. The cotyledons are partially separated by the decidual (maternal) septa. Most of the intervillous blood returns to the maternal circulation by way of the endometrial veins. A small portion enters neighboring cotyledons. The intervillous spaces are lined by syncytium.

Full-Term Placenta

- 15 to 25 cm
- 3 cm thick
- 500 to 600 g weight

maternal side

- 15 to 20 slightly cotyledons
- covered by a thin layer of decidua basalis

fetal surface

- covered the chorionic plate

velamentous insertion

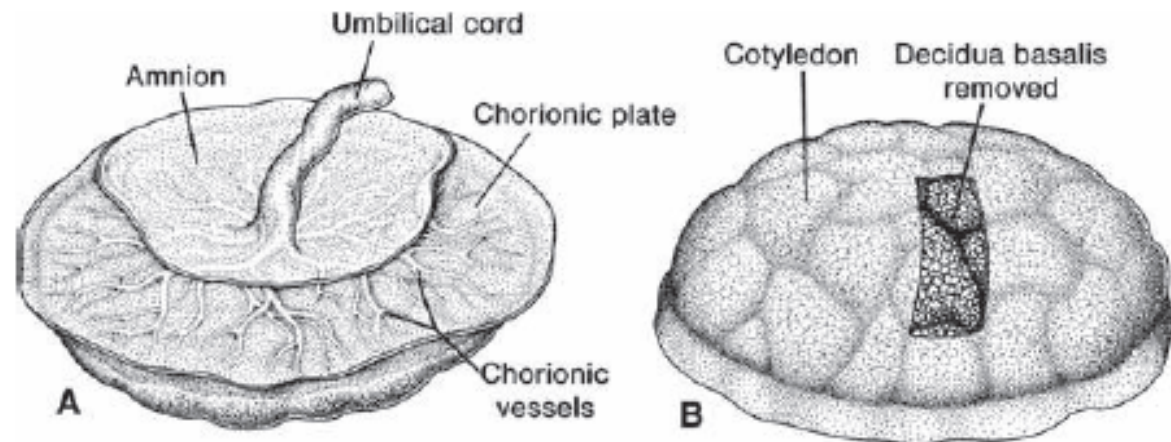


Figure 8.14 A full-term placenta. **A.** Fetal side. The chorionic plate and umbilical cord are covered by amnion. **B.** Maternal side showing the cotyledons. In one area, the decidua has been removed. The maternal side of the placenta is always carefully inspected at birth, and frequently one or more cotyledons with a whitish appearance are present because of excessive fibrinoid formation and infarction of a group of intervillous lakes.

Circulation of the Placenta

- 80 to 100 spiral arteries pierce the decidual plate
- enter the intervillous spaces
- approximately 150 mL

Placental membrane

1. Endothelial lining of fetal vessel
2. Connective tissue
3. Cytotrophoblast
4. Syncytiotrophoblast

- Placental barrier

- Hemochorial type

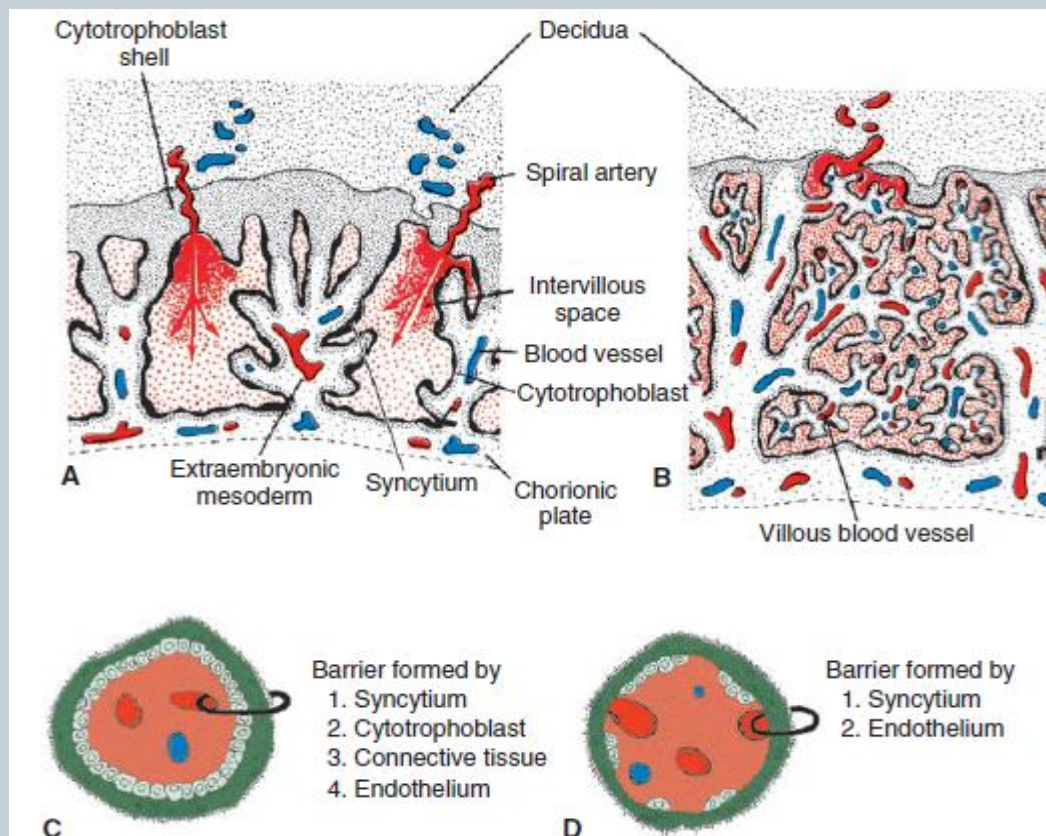


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Function of the placenta



1. Metabolit exchange (nutrient, IgG on 14th week)
2. Gas exchange (20-30 ml O₂/min)
3. Hormone production (syncytiotrophoblast)
 - Complement synthesis (3 month)
 - Maternal IgG
 - Progesteron(end of 4th month)
 - Esteriol (uterine growth & mammary glands development)
 - hCG (first 2 monthes)
 - Somatomammotropin (placental lactogen)

Clinical Correlates

Erythroblastosis Fetalis and Fetal Hydrops

Because some fetal blood cells escape across the placental barrier, there is a potential for these cells to elicit an antibody response by the mother's immune system. The basis for this response is the fact that more than 400 red blood cell antigens have been identified, and although most do not cause problems during pregnancy, some can stimulate a maternal antibody response against fetal blood cells. This process is an example of **isoimmunization**, and if the maternal response is sufficient, the antibodies will attack and hemolyze fetal red blood cells, resulting in **hemolytic disease of the fetus and newborn**. Previously, the disease was called **erythroblastosis fetalis** because in some cases severe hemolysis stimulated an increase in production of fetal blood cells called **erythroblasts**. However, this severity of anemia occurs only in a few cases such that hemolytic disease of the fetus and newborn is a more appropriate terminology. In rare cases, the anemia becomes so severe that **fetal hydrops** (edema and effusions into the body cavities) occurs, leading to fetal death (Fig. 8.15). Most severe cases are caused by antigens from the **CDE (Rhesus)** blood group system. The **D** or **Rh antigen** is the most dangerous, because immunization can result from a single exposure and occurs earlier and with greater severity with each succeeding pregnancy. The maternal antibody response occurs in cases when the fetus is D(Rh) positive and the mother is D(Rh) negative and is elicited when fetal red blood cells enter the maternal system because of small areas of bleeding at the surface of placental villi or at birth. This condition can be prevented by screening women at their first prenatal visit for Rh blood type and for the presence of anti-D antibodies to determine if she has been sensitized previously. In Rh-negative women without anti-D antibodies, recommendations include treatment with Rh

immunoglobulin at 28 weeks' gestation; following times when fetal-maternal mixing of blood may have occurred (e.g., after amniocentesis or pregnancy loss); and after delivery if the newborn is found to be Rh positive. Since the introduction of Rh immunoglobulin in 1968, hemolytic disease in the fetus and newborn in the United States has almost been eliminated.

Antigens from the **ABO blood group** can also elicit an antibody response, but the effects are much milder than those produced by the CDE group. About 20% of all infants have an ABO maternal incompatibility, but only 5% will be clinically affected. These can be effectively treated postnatally.



Figure 8.15 Fetal hydrops caused by the accumulation of fluid in fetal tissues.

Clinical Correlates

The Placental Barrier

Maternal steroidal hormones readily cross the placenta. Other hormones, such as thyroxine, do so only at a slow rate. Some synthetic progestins rapidly cross the placenta and may masculinize female fetuses. Even more dangerous was the use of the synthetic estrogen **diethylstilbestrol (DES)**, which easily crosses the placenta. This compound produced clear-cell carcinoma of the vagina and abnormalities of the cervix and uterus in females and in the testes of males in individuals who were exposed to the compound during their intrauterine life (see Chapter 9).

Although the placental barrier is frequently considered to act as a protective mechanism against damaging factors, many viruses—such as rubella, cytomegalovirus, Coxsackie, variola, varicella, measles, and poliomyelitis virus—traverse the placenta without difficulty. Once in the fetus, some viruses cause infections, which may result in cell death and birth defects (see Chapter 9).

Unfortunately, most drugs and drug metabolites traverse the placenta without difficulty, and many cause serious damage to the embryo (see Chapter 9). In addition, maternal use of heroin and cocaine can cause habituation in the fetus.

Amnion & umbilical cord

On 5th week

Primitive umbilical ring

- (1) Connecting stalk (allantois, two arteries & one vein)
- (2) yolk stalk (vitelline duct)
- (3) the connecting canal (Intra & extraembryonic cavities)

Primitive umbilical cord

1 & 2

Umbilical vessels & Wharton's jelly

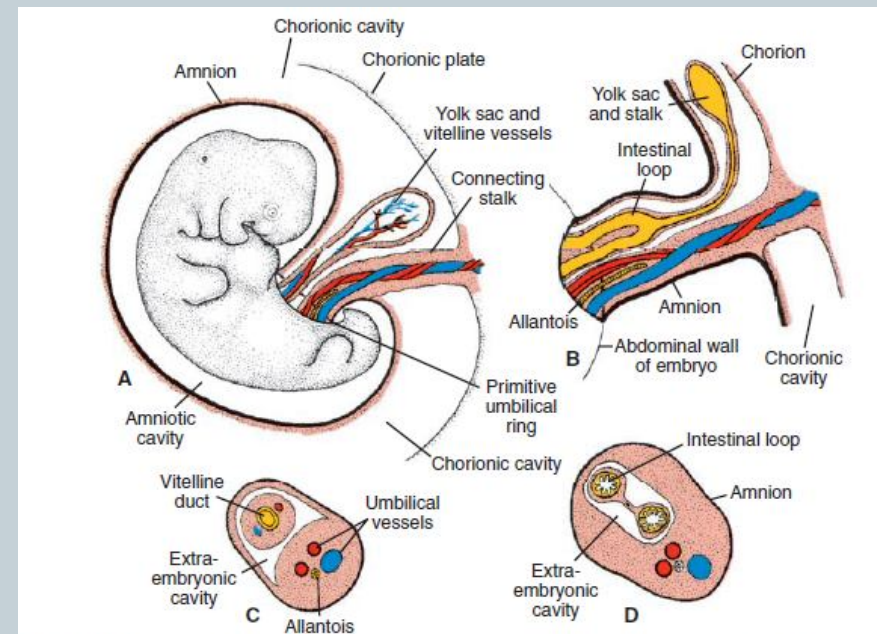


Figure 8.16 A. A 5-week embryo showing structures passing through the primitive umbilical ring. B. The primitive umbilical cord of a 10-week embryo. C. Transverse section through the structures at the level of the umbilical ring. D. Transverse section through the primitive umbilical cord showing intestinal loops protruding in the cord.

Clinical Correlates

Umbilical Cord Abnormalities

At birth, the umbilical cord is approximately 1 to 2 cm in diameter and 50 to 60 cm long. It is tortuous, causing **false knots**. Length of a cord reflects the amount of intrauterine movement of the fetus, and shortened cords have been observed in fetal movement disorders and with intrauterine constraint. An extremely long cord may encircle the neck of the fetus, usually without increased risk, whereas a short one may cause difficulties during delivery by pulling the placenta from its attachment in the uterus.

Normally, there are two arteries and one vein in the umbilical cord. In one in 200 newborns, however, only a **single umbilical artery** is present, and these babies have approximately a 20% chance of having cardiac and other vascular defects. The missing artery either fails to form (agenesis) or degenerates early in development.

Amniotic Bands

Occasionally, tears in the amnion result in **amniotic bands** that may encircle part of the fetus, particularly the limbs and digits. Amputations, **ring constrictions**, and other abnormalities, including craniofacial deformations, may result (Fig. 8.17). Origin of the bands is unknown.

Amniotic Fluid

Hydramnios or **polyhydramnios** is the term used to describe an excess of amniotic fluid (1,500 to 2,000 mL), whereas **oligohydramnios** refers to a decreased amount (<400 mL). Both conditions are associated with an increase in the incidence of birth defects. Primary causes of hydramnios include idiopathic causes (35%), maternal diabetes (25%), and congenital malformations, including central nervous system disorders (e.g., anencephaly) and gastrointestinal defects (atresias, e.g., esophageal) that prevent the infant from swallowing the fluid. Oligohydramnios is a rare occurrence that may result from renal agenesis. The lack of fluid in the amniotic cavity may constrict the fetus and cause club foot or there may be too little fluid for the fetus to "breathe" into its lungs resulting in lung hypoplasia.

Premature rupture of the membranes (PROM) refers to rupture of the membranes before uterine contractions begin and occurs in 10% of pregnancies. **Preterm PROM** occurs before 37 completed weeks of pregnancy, occurs in 3% of pregnancies, and is a common cause of preterm labor. Causes of preterm PROM are unknown, but risk factors include a previous pregnancy affected by prematurity or PROM, black race, smoking, infections, and severe polyhydramnios.

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Figure 8.17 Limb abnormalities caused by amniotic bands. **A.** Limb constriction ring. **B.** Digit amputation (big toe) and ring constriction (second toe).

Placental changes at the & of pregnancy

Exchange reduction

1. Increase in fibrous tissue in villus core
2. thickening of basement membrane in fetal capillaries
3. Obliterative changes in villus capillaries
4. Fibrinoid deposition on villus surface

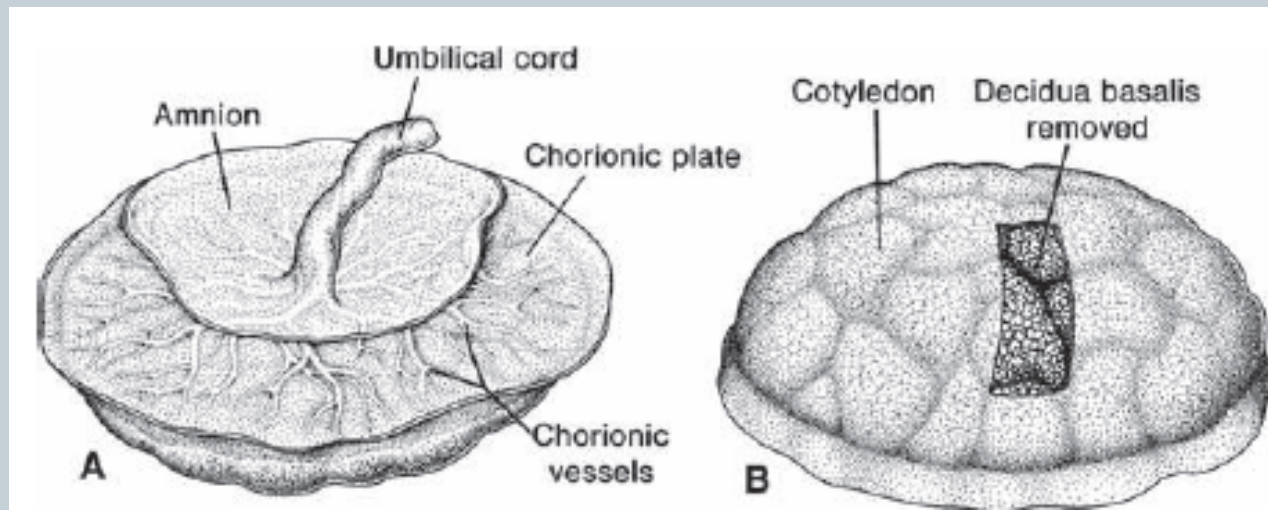


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Amniotic fluid



- Amniotic cells
- Maternal blood

- 10th week: 30 ml
- 20th week: 450 ml
- 37th week: 800-1000 ml

Functions:

1. Absorb jolts
2. Prevention of embryo adherence to amnion
3. Fetal movement

fluid replacement: Each 3 h

Beginning of 5th month

Fetus swallows amniotic fluid (400ml)

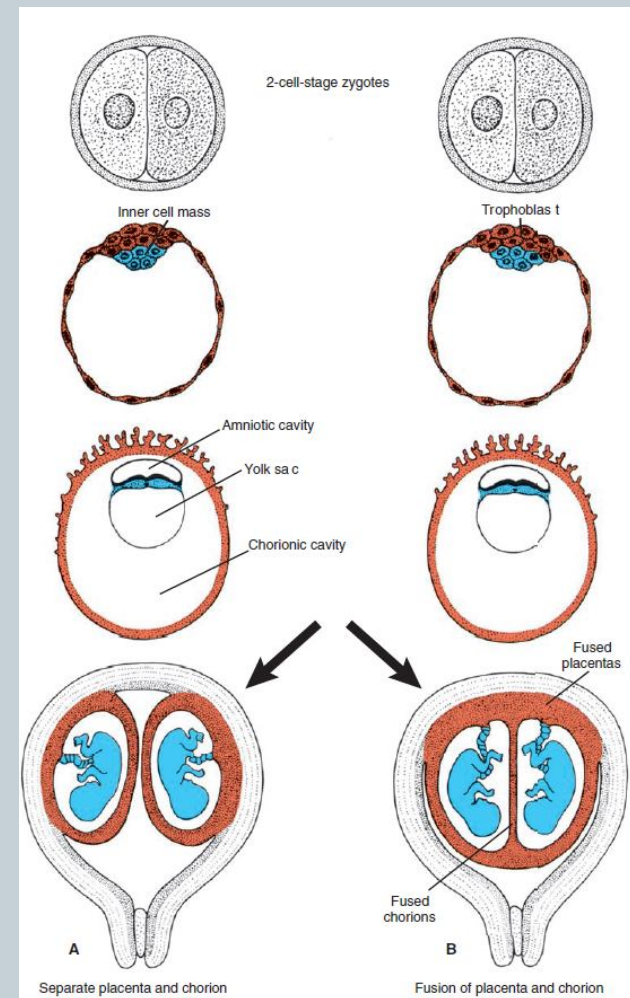
5th month urine added to amniotic fluid

Fetal membrane in twins

- 90% dizygotic (fraternal)

Increases in dizygotic twins:

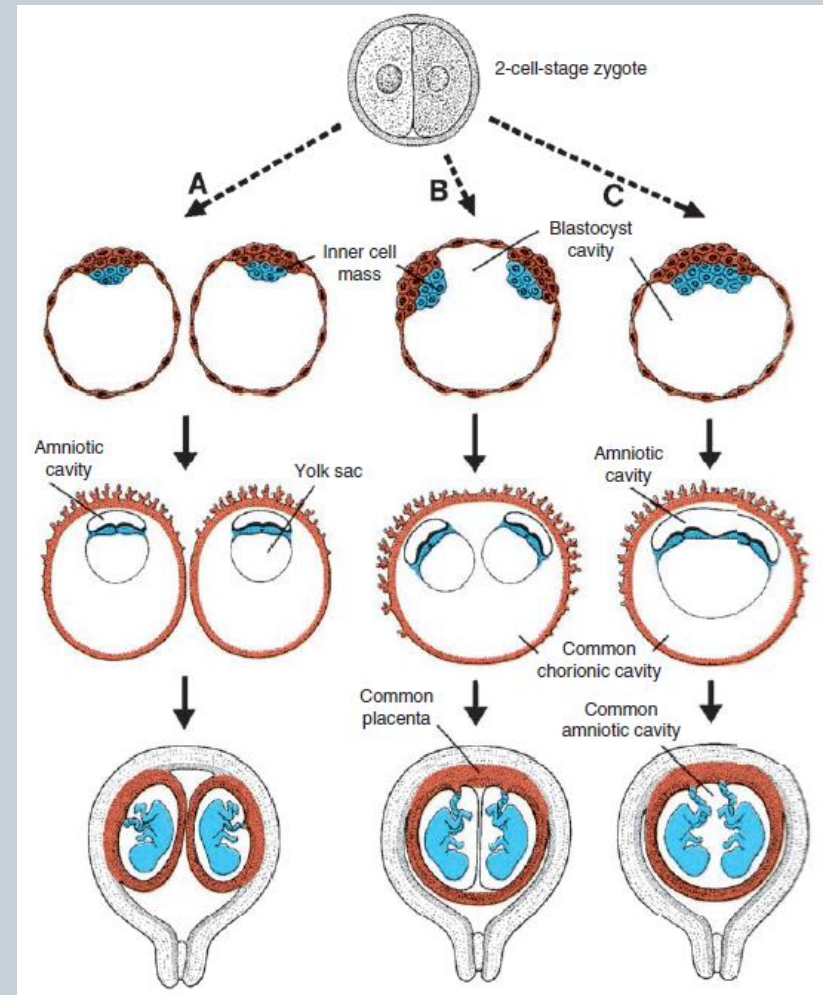
- Maternal age increase
- ART
- Erythrocyte mosaicism



Fetal membrane in twins

- Monozygotic (identical)
 - 3-4 in 1000
1. 2 cells embryo (A)
 2. Blastocyst (more common) (B)
 3. Bilaminar disc (C)

Triplet
1 in 7,600



Parturition (birth)



- During last 2 to 4 weeks of pregnancy

Labor:

1. Effacement (cervix thinning, shortening & dilatation)
2. Fetus delivery
3. Placenta & fetal membrane delivery

Clinical Correlates

Abnormalities Associated with Twins

Twin pregnancies have a high incidence of perinatal mortality and morbidity and an increased risk for preterm delivery. Approximately 60% of twins are born preterm and also have a high incidence of being low birth weight. Both of these factors put twin pregnancies at great risk and twin pregnancies have an infant mortality rate three times higher than that for singletons.

The incidence of twinning may be much higher than the number observed at birth because twins are conceived more often than they are born. Many twins die before birth, and some studies indicate that only 29% of women pregnant with twins actually give birth to two infants. The term **vanishing twin** refers to the death of one fetus. This disappearance, which occurs in the first trimester or the early second trimester, may result from resorption or formation of a fetus papyraceus (Fig. 8.20).

Another problem leading to increased mortality among twins is twin-twin transfusion syndrome, which occurs in 15% of monochorionic monozygotic

pregnancies. In this condition, placental vascular anastomoses, which occur in a balanced arrangement in most monochorionic placentas, are formed, so that one twin receives most of the blood flow, and flow to the other is compromised. As a result, one twin is larger than the other (Fig. 8.21). The outcome is poor, with the death of both twins occurring in 50% to 70% of cases.

At later stages of development, partial splitting of the primitive node and streak may result in formation of conjoined twins. These twins are classified according to the nature and degree of their union (Figs. 8.22 and 8.23). Occasionally, monozygotic twins are connected only by a common skin bridge or by a common liver bridge. The type of twins formed depends on when and to what extent abnormalities of the node and streak occurred. Misexpression of genes, such as *Goosecoid*, may also result in conjoined twins. Many conjoined twins have survived, including the most famous pair, Chang and Eng, who were joined at the abdomen and who traveled to England and the United States on exhibitions in the mid-1800s. Finally settling in North Carolina, they farmed and fathered 21 children with their two wives.



Figure 8.20 Fetus papyraceus. One twin is larger, and the other has been compressed and mummified, hence the term *papyraceus*.



Figure 8.21 Monozygotic twins with twin transfusion syndrome. Placental vascular anastomoses produced unbalanced blood flow to the two fetuses.

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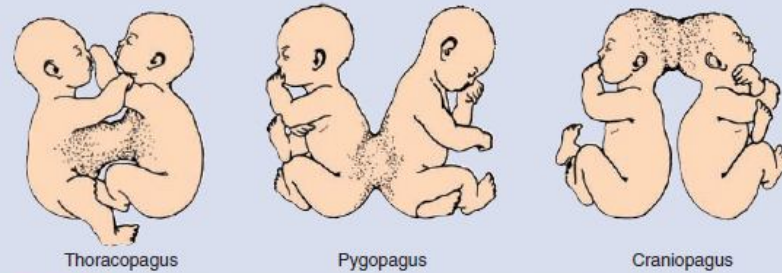


Figure 8.22 Thoracopagus, pygopagus, and craniopagus twins (*pagus*; fastened). Conjoined twins can be separated only if they have no vital parts in common.



A



B

Figure 8.23 Examples of conjoined twins. **A.** Dicephalus (two heads). **B.** Craniopagus (joined at the head and thorax).

In brother-sister pairs of dizygotic twins, testosterone from the male twin can affect development of the female. Thus, females in such pairs tend to have square jaws, larger teeth, perform better on

spatial-ability tests and have better ball skills than most girls. They are 15% less likely to get married and they have fertility problems, producing 25% fewer children.

Clinical Correlates



Preterm Birth

Factors initiating labor are not known and may involve “**retreat from maintenance of pregnancy**,” in which pregnancy-supporting factors (e.g., hormones) are withdrawn, or **active induction** caused by stimulatory factors targeting the uterus. Probably, components of both phenomena are involved. Unfortunately, a lack of knowledge about these factors has restricted progress in preventing **preterm birth**. Preterm birth (delivery before 37 completed weeks) of **premature infants** occurs in approximately 12% of births in the United States and is a leading cause of infant mortality and also contributes significantly to morbidity. It is caused by preterm PROM, premature onset of labor, or pregnancy complications requiring premature delivery. Risk factors include previous preterm birth, black race; multiple gestations; infections, such as periodontal disease and bacterial vaginosis; and low maternal body-mass index.