

Introduction to General embryology

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- From a single cell to a baby in 9 months
- The study of these phenomena is called **embryology**, and the field includes investigations of the **molecular**, **cellular**, and **structural** factors contributing to the formation of an organism.
- Embryonic development can be divided into different developmental phases.

- **Embryogenesis (organogenesis): first 8 weeks** of human development
 - ❑ Establishment of the **organ primordia** from a single cell
- **Fetal period:** From 9th week to birth
 - ❑ Differentiation and growth
- **Teratology:** Study of the embryological causes for **birth defects, genetic or environmental**

- From **fertilisation**. On this basis human pregnancy lasts about **266 ± 3** , days or **38 weeks**.
- Obstetricians time pregnancy from the **last day of the menstrual period**, on the assumption that fertilisation takes place **2 weeks later**, **280 days** or **40 weeks**.
- **Trimester**
 - 1/3 of the normal length of pregnancy

Gametogenesis

- Humans have approximately **23,000 genes** on **46 chromosomes**.
- Traits of a new individual are determined by specific genes on chromosomes inherited from the father and the mother.
- In **somatic** cells, chromosomes appear as **23 homologous** pairs to form the **diploid** number of 46.
- **Autosomes** are sex cells, 22 pairs of matching chromosomes, the and one pair of sex chromosomes.
- Sex pair is XX, female and if XY, male.
- The development and maturation of sex cells through **meiosis**

- **Premordial germ cells(PGC)**, appear in the wall of **yolk sac** at **4th week**, migrate to **indifferent gonad**, which form male and female gamet
- In preparation for fertilization, germ cells undergo **gametogenesis**, which include **meiosis**, and **cytodifferentiation**

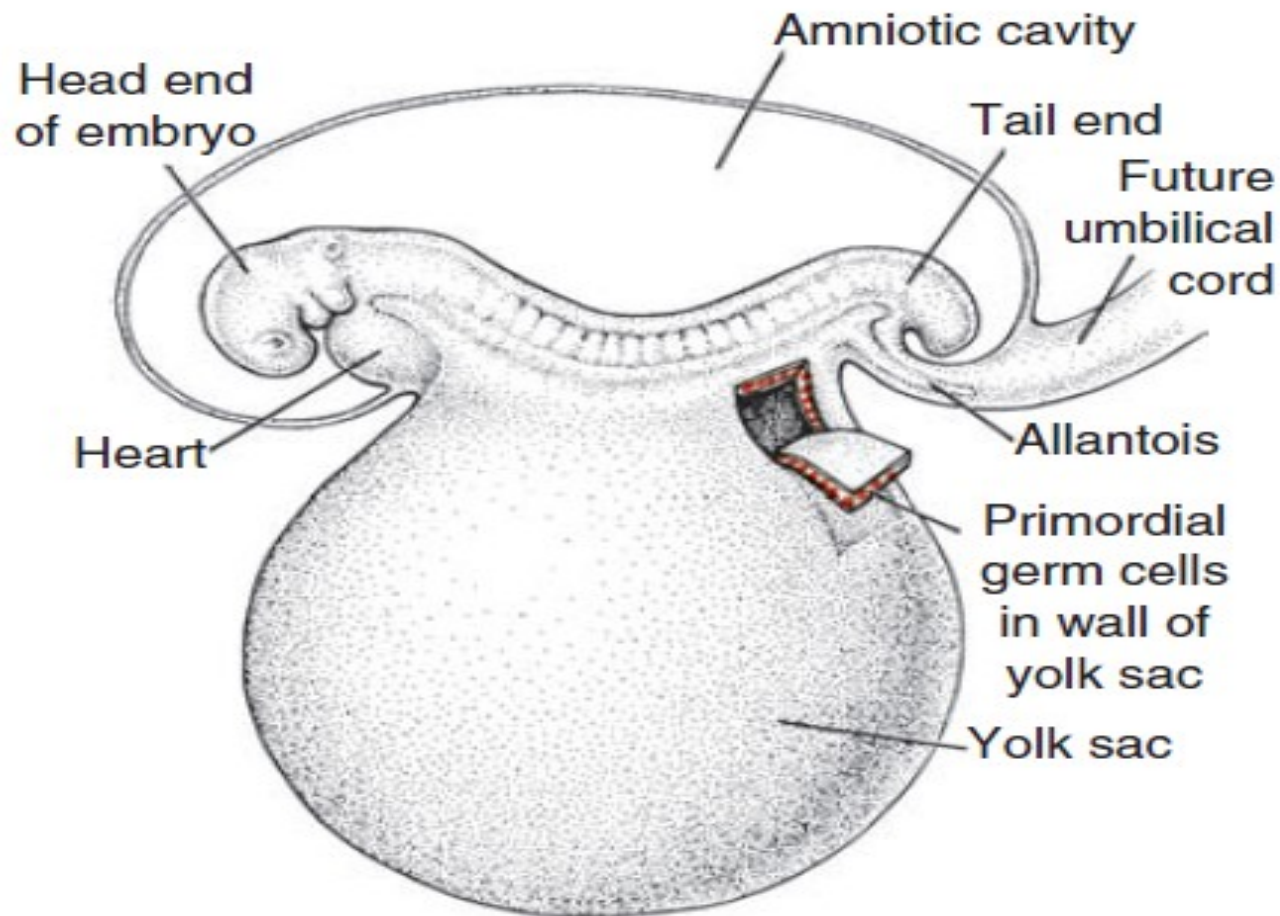


Figure 2.1 An embryo at the end of the third week, showing the position of PGCs in the wall of the yolk sac, close to the attachment of the future umbilical cord. From this location, these cells migrate to the developing gonad.

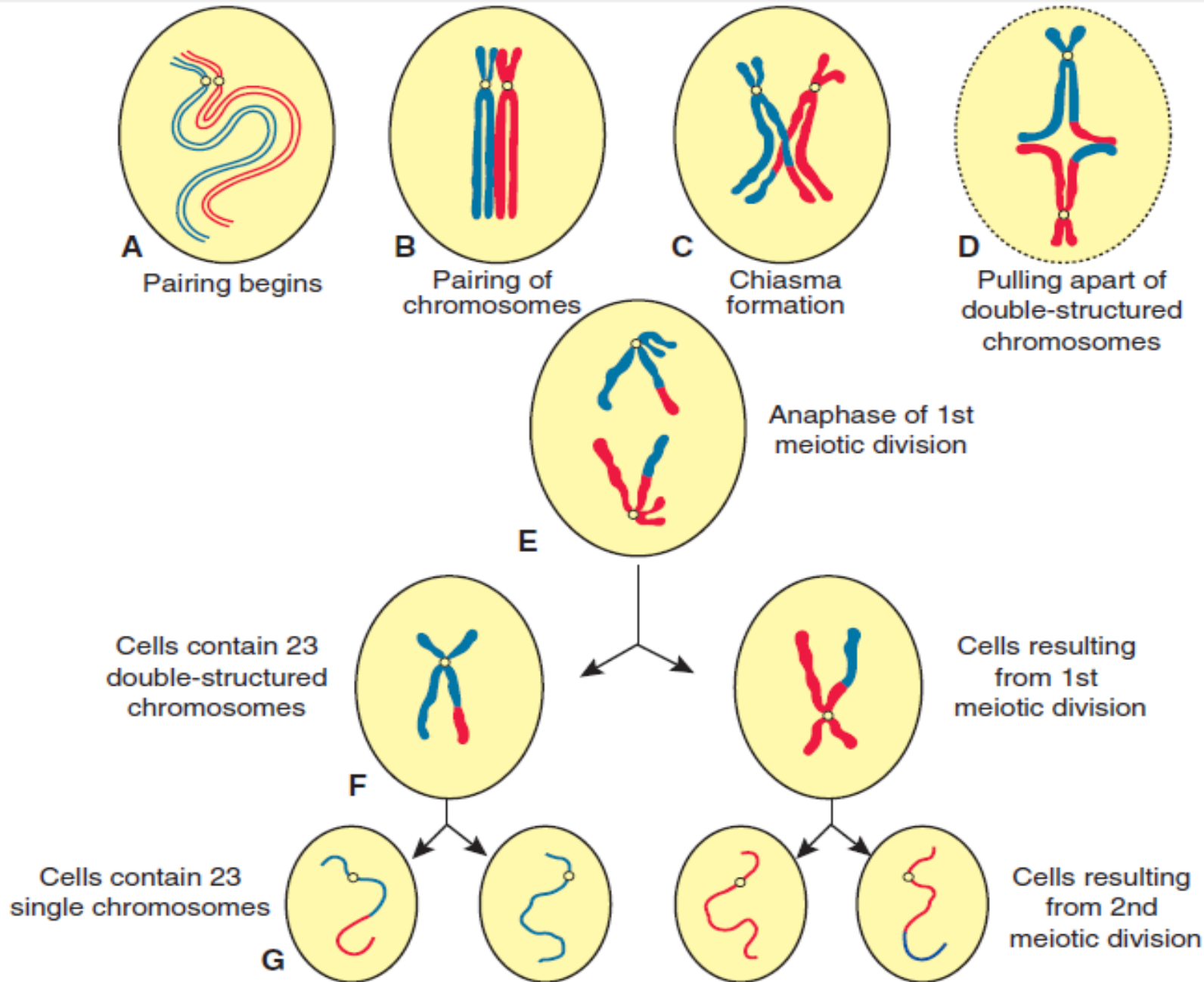
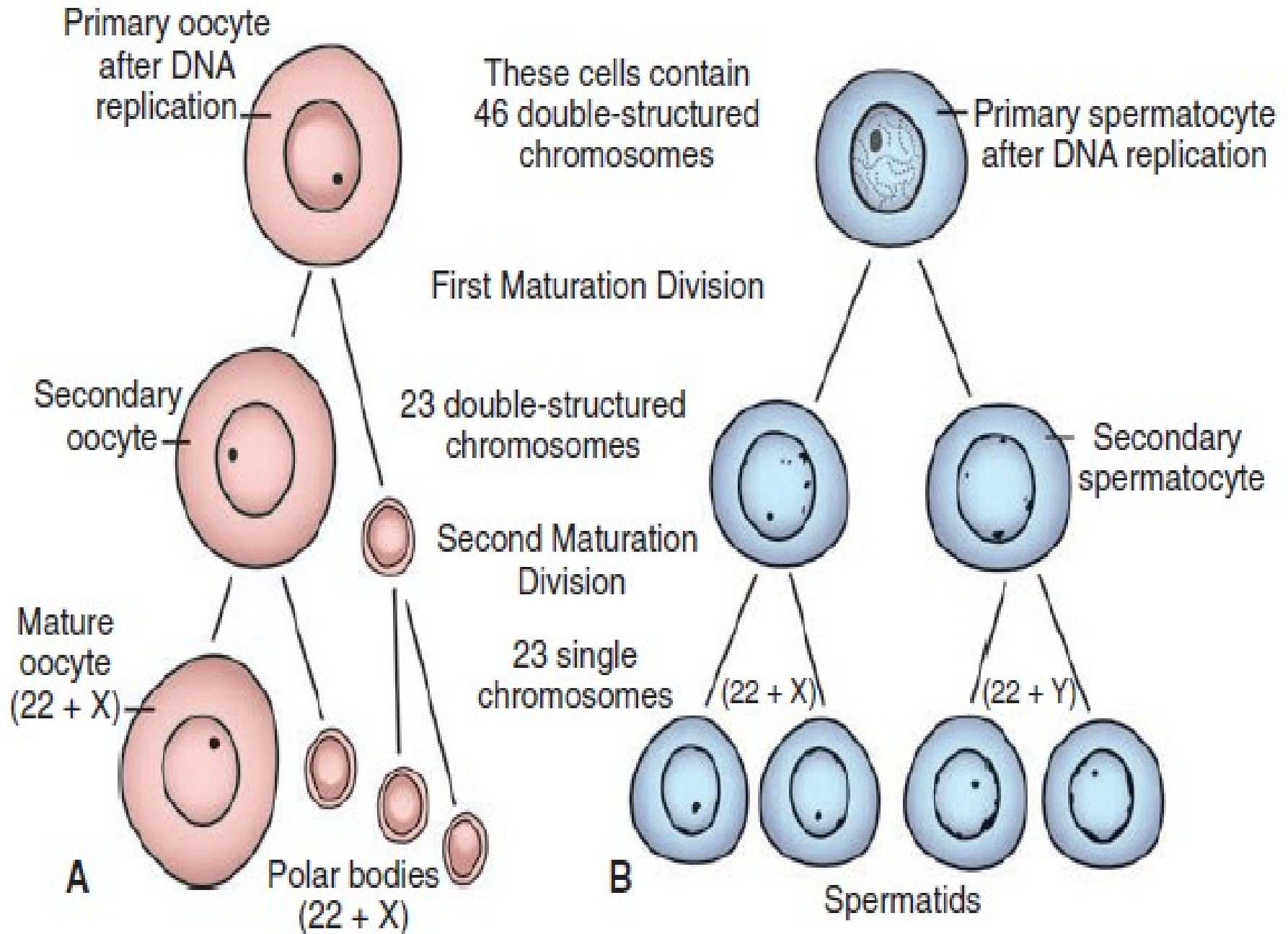


Figure 2.4 First and second meiotic divisions. **A.** Homologous chromosomes approach each other. **B.** Homologous chromosomes pair, and each member of the pair consists of two chromatids. **C.** Intimately paired homologous chromosomes interchange chromatid fragments (crossover). Note the chiasma. **D.** Double-structured chromosomes pull apart. **E.** Anaphase

Spermatogenesis

- At week 4, **primordial germ cells** arrive in the **indifferent gonad** and remain **dormant** until puberty.
- **At puberty**, primordial germ cells differentiate into **type A spermatogonia** => **type B spermatogonia**. => **primary spermatocytes** => **2 secondary spermatocytes** => **2 spermatids** => **mature spermatozoa**.

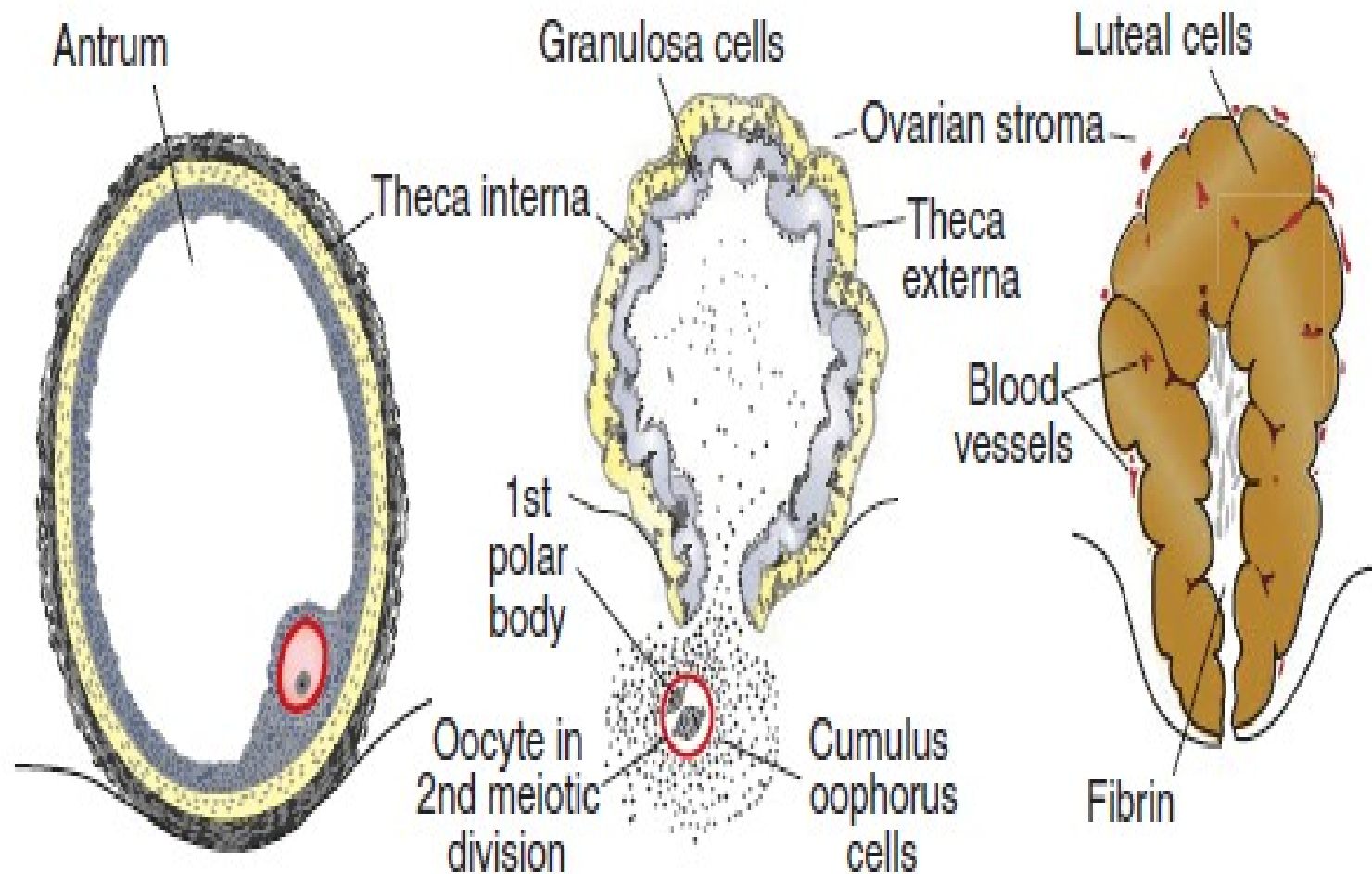


OÖGENESIS

- At week 4, primordial germ cells arrive in the indifferent gonad and **differentiate** into **oögonia**.
- Oögonia enter **meiosis I** to form **primary oöcytes**.
- Arrested the first time in **prophase** (diplotene) of meiosis I and remain arrested until **puberty**
- All primary oöcytes are formed by **month 5** of fetal life;
- **At puberty**, during each monthly cycle a primary oöcyte becomes **unarrested** and **completes meiosis I** to form a **secondary oöcyte** and **polar body**.
- At fertilization, rapidly completes **meiosis II**.

ovarian cycle

- Monthly a number of primary follicles begin to grow, but usually only one reaches full maturity, 15 to 20
- **Only one oocyte** is discharged at ovulation.
- At ovulation, the oocyte is in **metaphase** of the **second meiotic** division and is surrounded by the zona pellucida and some **granulosa cells**
- Sweeping action of **tubal fimbriae** carries the oocyte into the uterine tube.



A Mature vesicular follicle

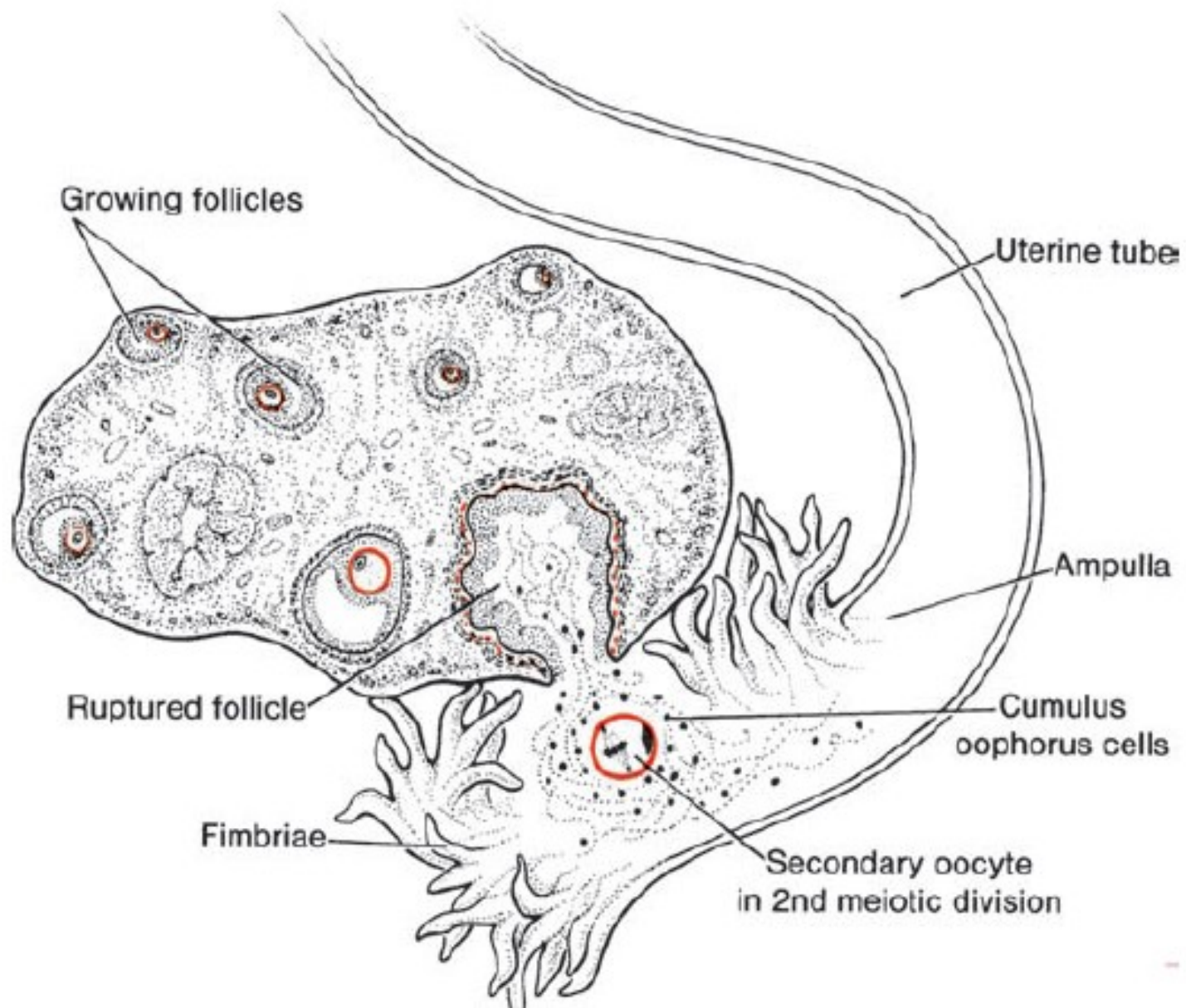
B Ovulation

C Corpus luteum

WEEK 1:

Fertilization

- occurs in the **ampulla** of the uterine tube when the male and female pronuclei fuse to form a zygote.
- Prior to fertilization, spermatozoa undergo 2 changes in the female genital tract:
 1. **Capacitation** consists of the **removal** of several proteins from **acrosome**
 2. **Cortical reaction: Hydrolytic** enzymes are released from the **acrosome** to penetrate the **zona pellucida** and prevent polyspermy.



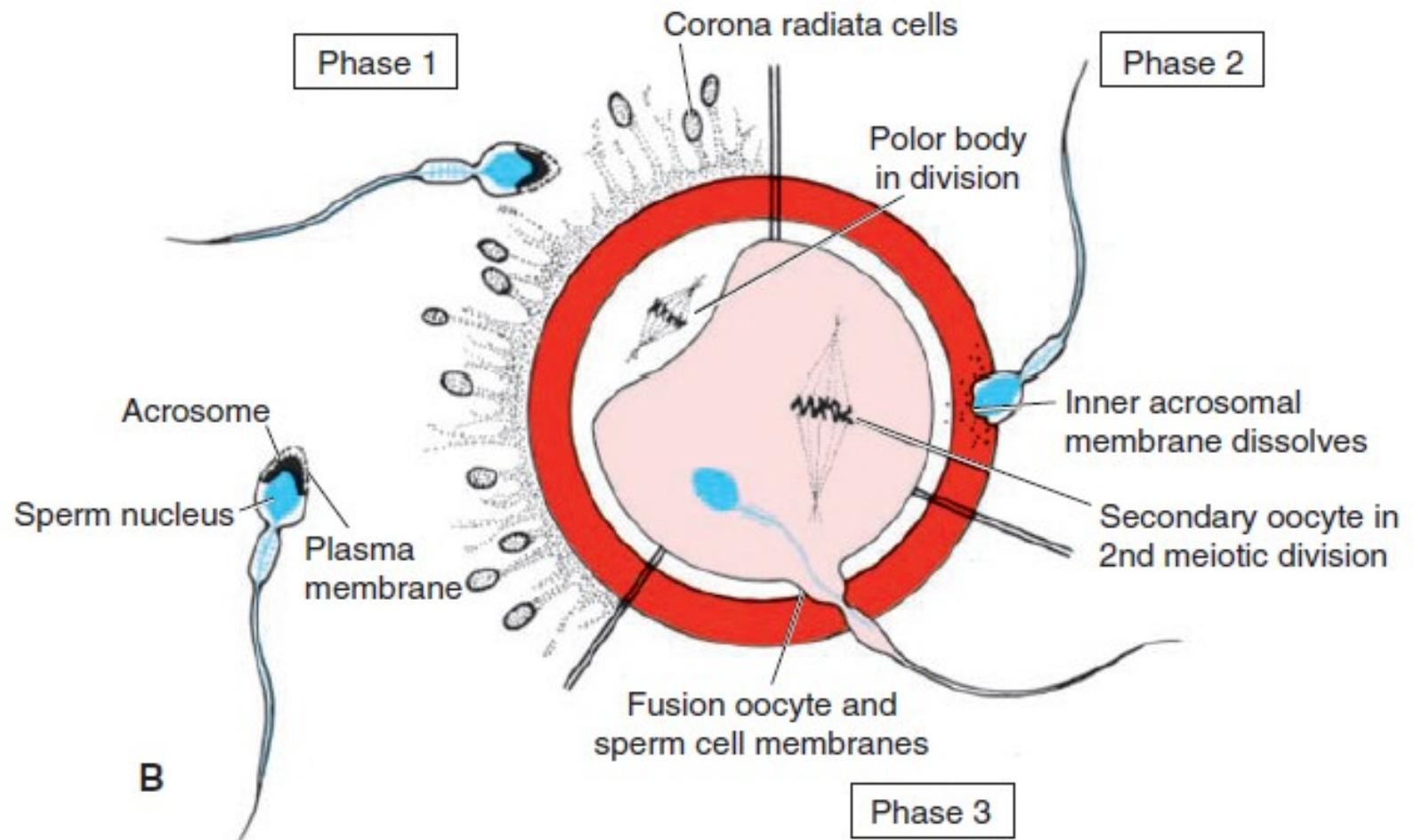


Figure 3.5 A. Scanning electron micrograph of sperm binding to the zona pellucida. **B.** The three phases of oocyte penetration. In phase I, spermatozoa pass through the corona radiata barrier; in phase 2, one or more spermatozoa penetrate the zona pellucida; in phase 3, one spermatozoon penetrates the oocyte membrane while losing its own plasma membrane. Inset shows normal spermatocyte with acrosomal head cap.

- As soon as the spermatocyte has entered the **oocyte**,
 1. The oocyte **finishes** its **second meiotic** division
 2. The **zona pellucida** becomes **impenetrable** to other spermatozoa
 3. The **head** of the sperm separates from the **tail**,
- The results of **fertilization** are
 1. Restoration of the **diploid number** of chromosomes
 2. Determination of **chromosomal sex**
 3. Initiation of **cleavage**

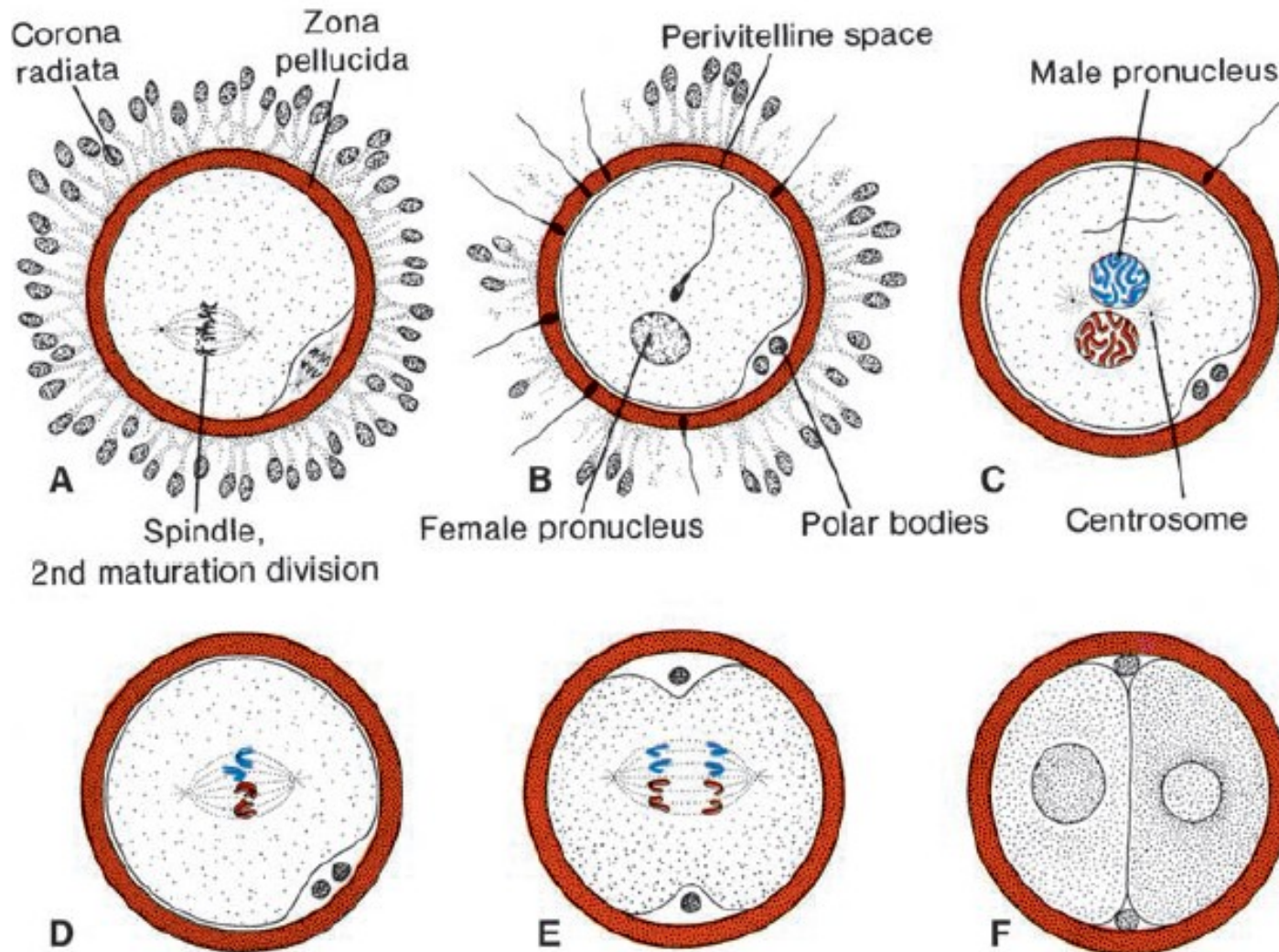
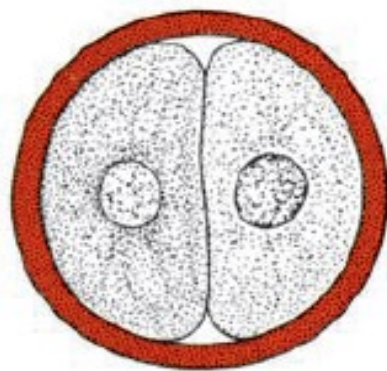
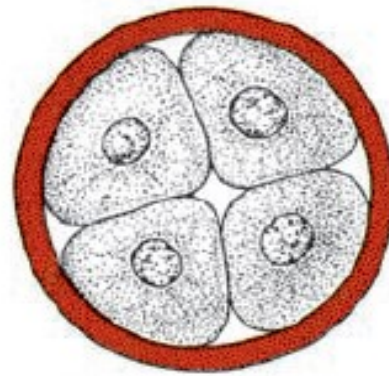


Figure 3.6 **A.** Oocyte immediately after ovulation, showing the spindle of the second meiotic division. **B.** A spermatozoon has penetrated the oocyte, which has finished its second meiotic division. Chromosomes of the oocyte are arranged in a vesicular nucleus, the female pronucleus. Heads of several sperm are stuck in the zona pellucida. **C.** Male and female pronuclei. **D, E.** Chromosomes become arranged on the spindle, split longitudinally, and move to opposite poles. **F.** Two-cell stage.

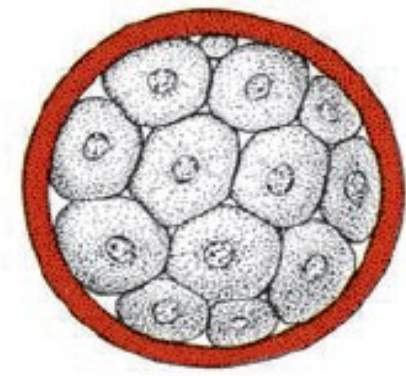
- During the first 4–5 days, zygote undergoes rapid mitotic division (**cleavage**) =>**blastomeres**.
- Then becomes the **morula (32-cell stage)**.
- blastocyst consists an inner cell mass known as the **embryoblast**, and the outer cell mass known as the **trophoblast**, which becomes the **placenta**.
- At the end of **week 1**, the **trophoblast** differentiates into the **cytotrophoblast** and **syncytiotrophoblasta** and then **implantation** begins.



Two-cell stage



Four-cell stage

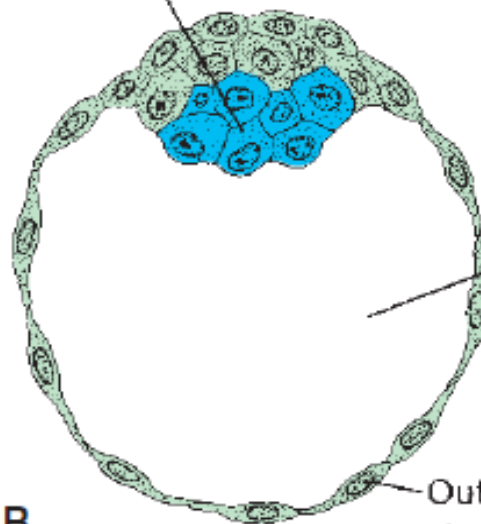


Morula

Inner cell mass
or embryoblast

Uterine epithelium

Uterine stroma



B

Blastocyst cavity

Outer cell mass
or trophoblast



Trophoblast
cells

Embryoblast

C

Figure 3.10 **A.** Section of a 107-cell human blastocyst showing inner cell mass and trophoblast cells. **B.** Schematic representation of a human blastocyst recovered from the uterine cavity at approximately 4.5 days. Blue, inner cell mass or embryoblast; green, trophoblast. **C.** Schematic representation of a blastocyst at the sixth day of development showing trophoblast cells at the embryonic pole of the blastocyst penetrating the uterine mucosa. The human blastocyst begins to penetrate the uterine mucosa by the sixth day of development.

Implantation

- Zona pellucida must **degenerate**.
- Blastocyst usually implants within the **posterior wall** of the uterus on **endometrium**

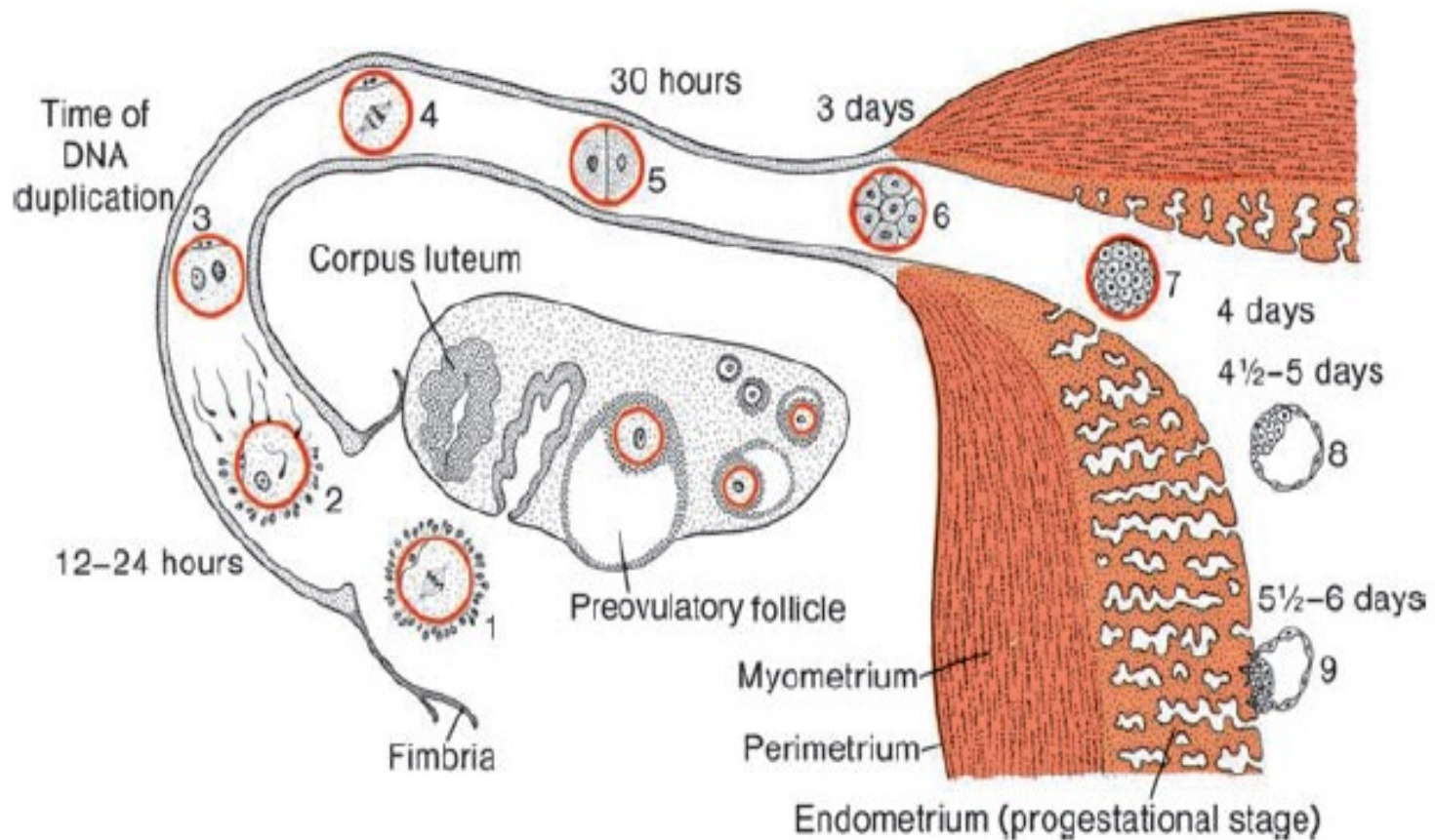


Figure 3.11 Events during the first week of human development. 1, oocyte immediately after ovulation; 2, fertilization, approximately 12 to 24 hours after ovulation; 3, stage of the male and female pronuclei; 4, spindle of the first mitotic division; 5, two-cell stage (approximately 30 hours of age); 6, morula containing 12 to 16 blastomeres (approximately 3 days of age); 7, advanced morula stage reaching the uterine lumen (approximately 4 days of age); 8, early blastocyst stage (approximately 4.5 days of age; the zona pellucida has disappeared); and 9, early phase of implantation (blastocyst approximately 6 days of age). The ovary shows stages of transformation between a primary follicle and a preovulatory follicle as well as a corpus luteum. The uterine endometrium is shown in the progestational stage.

WEEK 2:

- Embryoblast differentiates into the **epiblast** and **hypoblast**
- **Epiblast** forms the **amniotic cavity** and **extraembryonic mesoderm**
- **Hypoblast** form the **primary yolk sac**.
- **fusion** of **epiblast** and **hypoblast** cells from **prechordal plate**, future **mouth**.

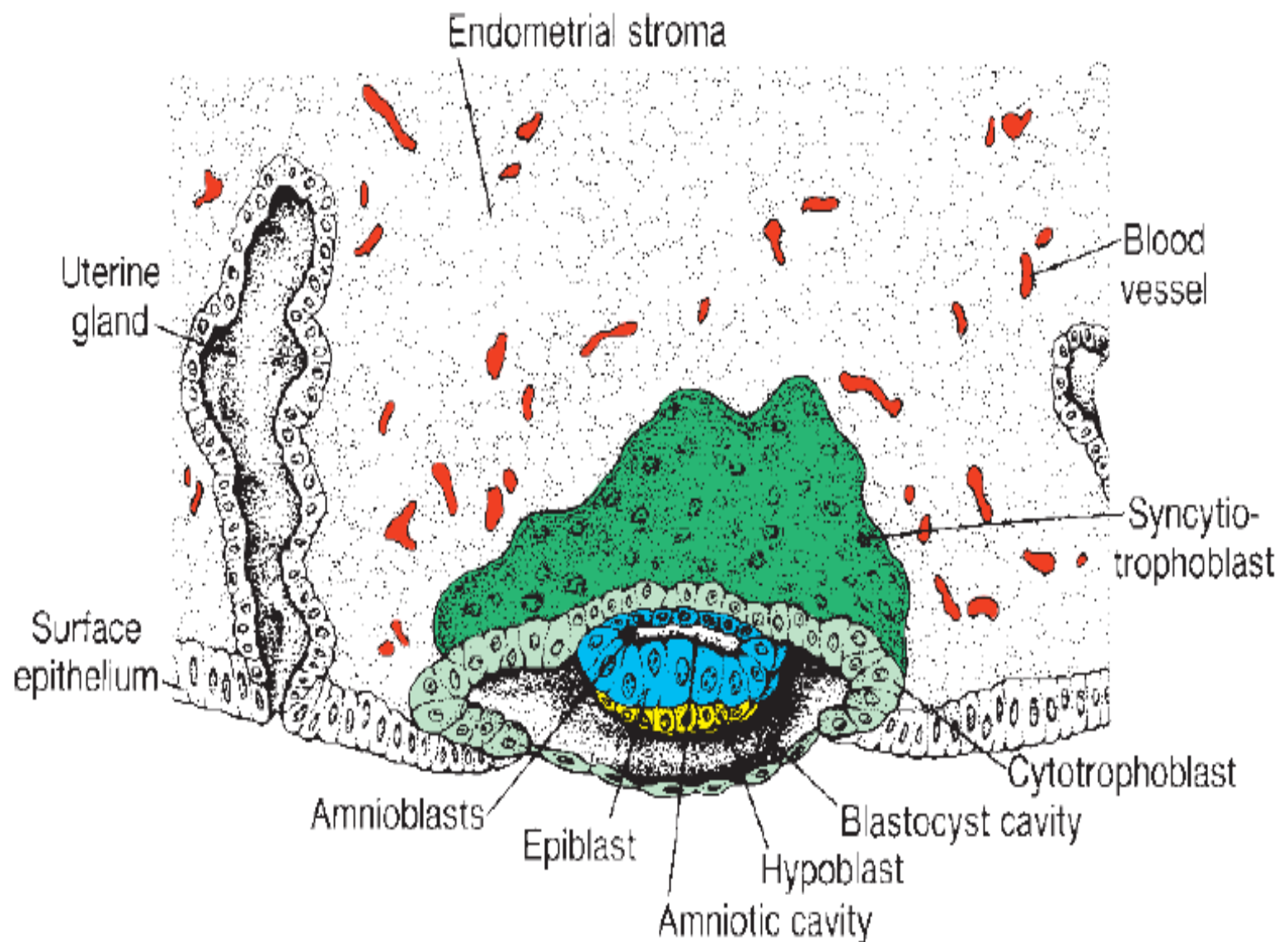


Figure 4.1 A 7.5-day human blastocyst, partially embedded in the endometrial stroma. The trophoblast consists of an inner layer with mononuclear cells, the cytotrophoblast, and an outer layer without distinct cell boundaries, the syncytiotrophoblast. The embryoblast is formed by the epiblast and hypoblast layers. The amniotic cavity appears as a small cleft.

- Extraembryonic **somatic** mesoderm: lines the **cytotrophoblast**, forms the **connecting stalk**, and covers the **amnion**.
- Extraembryonic **visceral** mesoderm: covers the **yolk sac**
- **connecting stalk** suspends the **conceptus** within the chorionic cavity.
- wall of the **chorionic cavity** is called the **chorion**, consisting of **extraembryonic somatic mesoderm**, the **cytotrophoblast**, and the **syncytiotrophoblast**

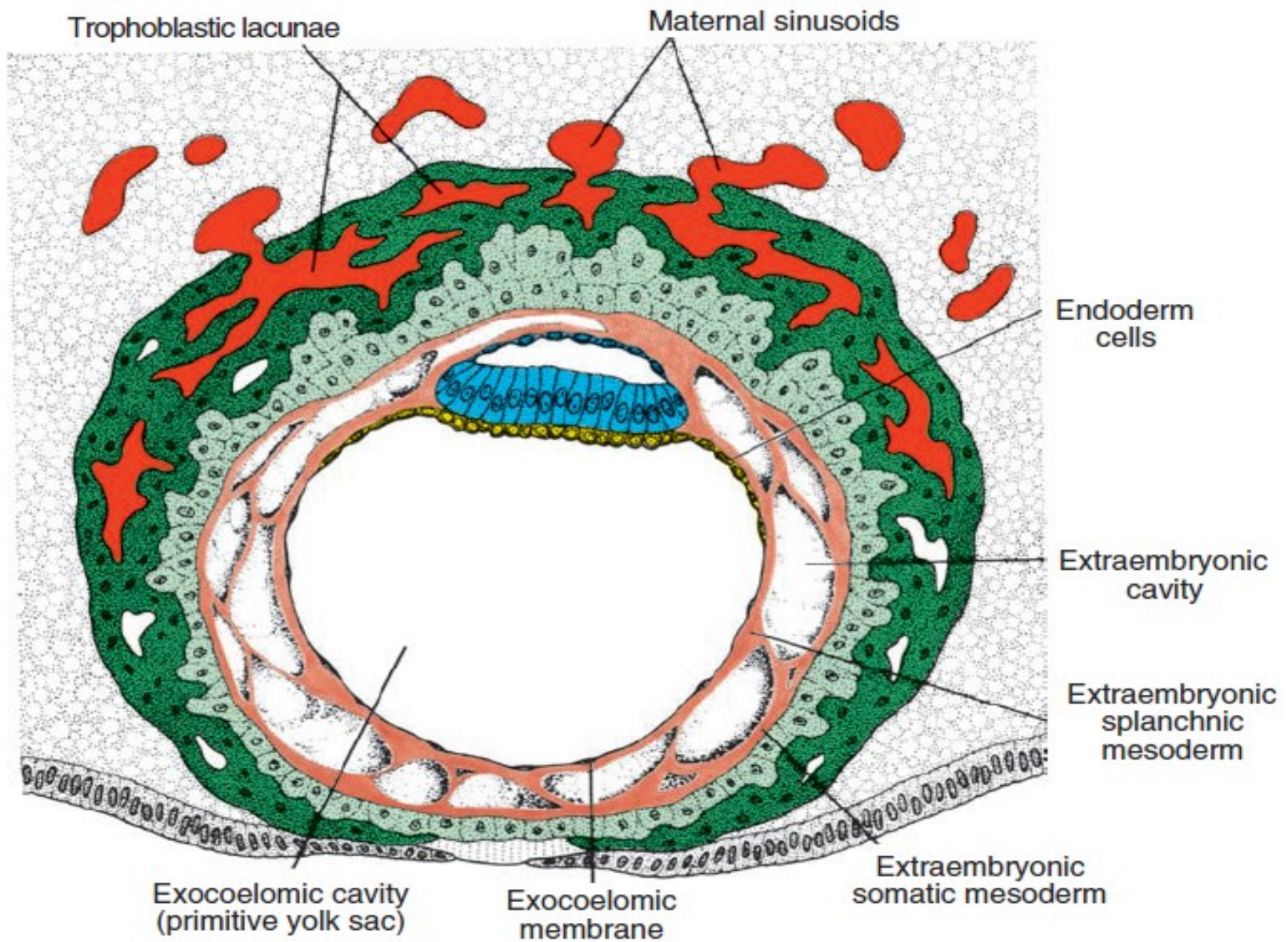


Figure 4.4 Human blastocyst of approximately 12 days. The trophoblastic lacunae at the embryonic pole are in open connection with maternal sinusoids in the endometrial stroma. Extraembryonic mesoderm proliferates and fills the space between the exocoelomic membrane and the inner aspect of the trophoblast.

- **Syncytiotrophoblast:** Produce **Human chorionic gonadotropin (hCG)**, which stimulates **progesterone** production by the **corpus luteum**.
- The **cytotrophoblast** is **mitotically** active.
- **Hematopoiesis** (formation of blood cells) occurs initially in the **mesoderm** surrounding the yolk sac (up to 6 weeks) and later in the **fetal liver, spleen, thymus** (6 weeks to third trimester), and **bone marrow**.

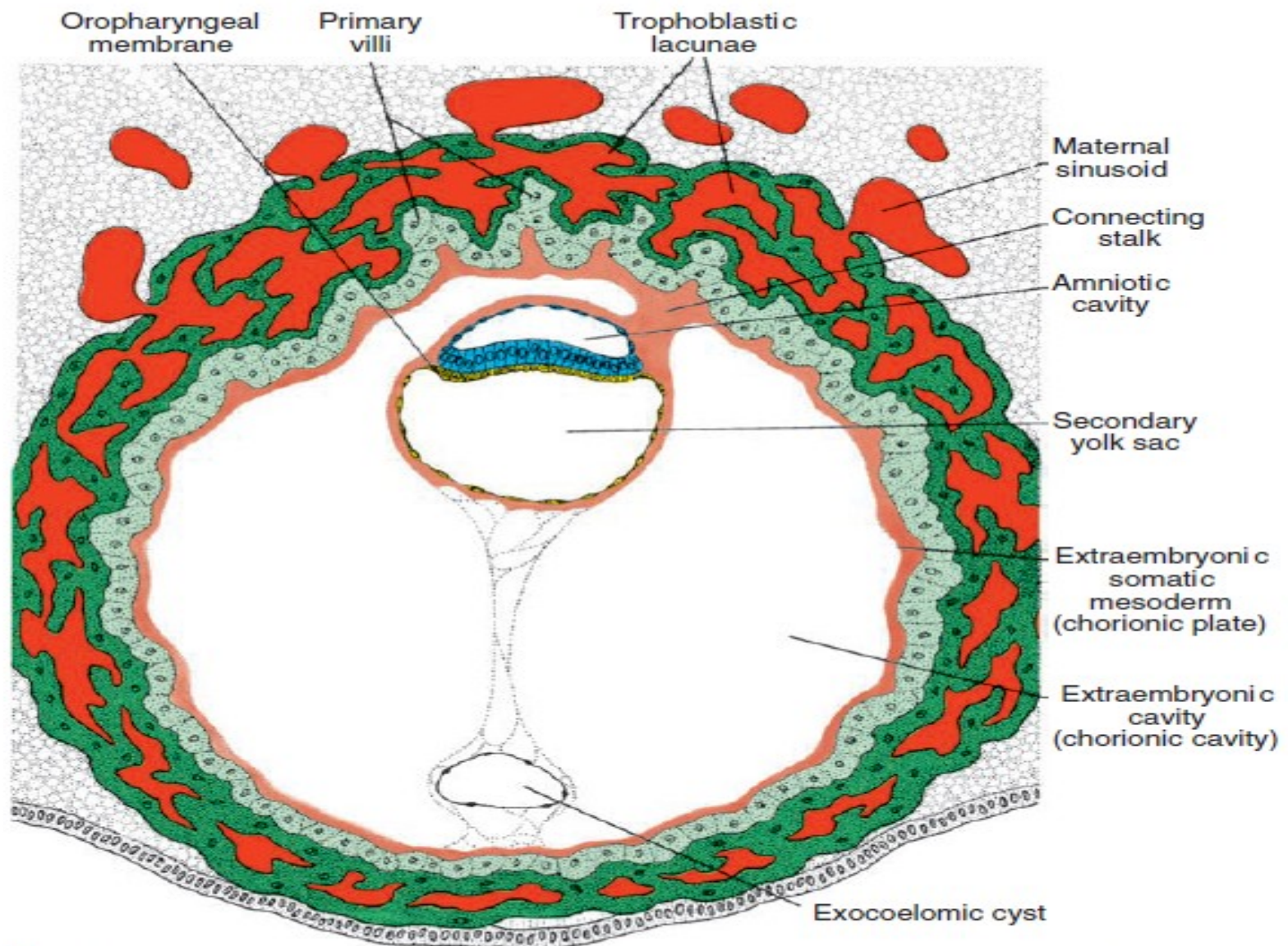
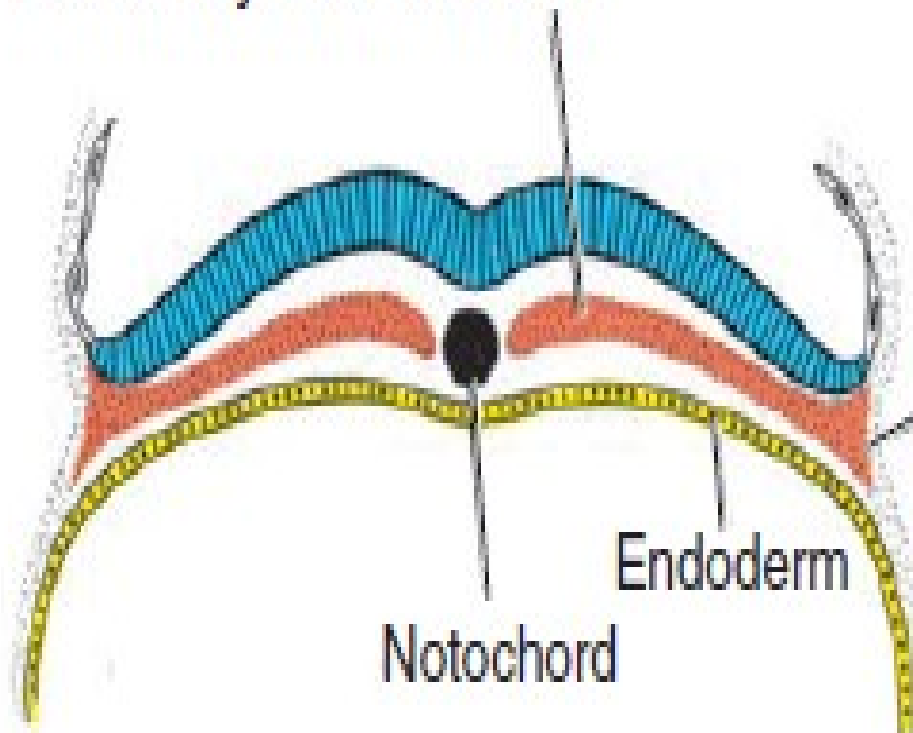


Figure 4.6 A 13-day human blastocyst. Trophoblastic lacunae are present at the embryonic as well as the abembryonic pole, and the uteroplacental circulation has begun. Note the primary villi and the extraembryonic coelom or **chorionic cavity**. The secondary yolk sac is entirely lined with endoderm.

Week 3 Gastrulation

- Gastrulation converts this **bilaminar disc** into **three layers**.
- An upper ectoderm **ectoderm**, a middle **mesoderm** and a lower **endoderm**
- Ectoderm forms **neuroectoderm** and **neural crest cells**.
- Mesoderm forms **paraxial mesoderm** (35 pairs of somites)
- Endoderm forms **epithelial lining**

Intraembryonic mesoderm



Extraembryonic mesoderm

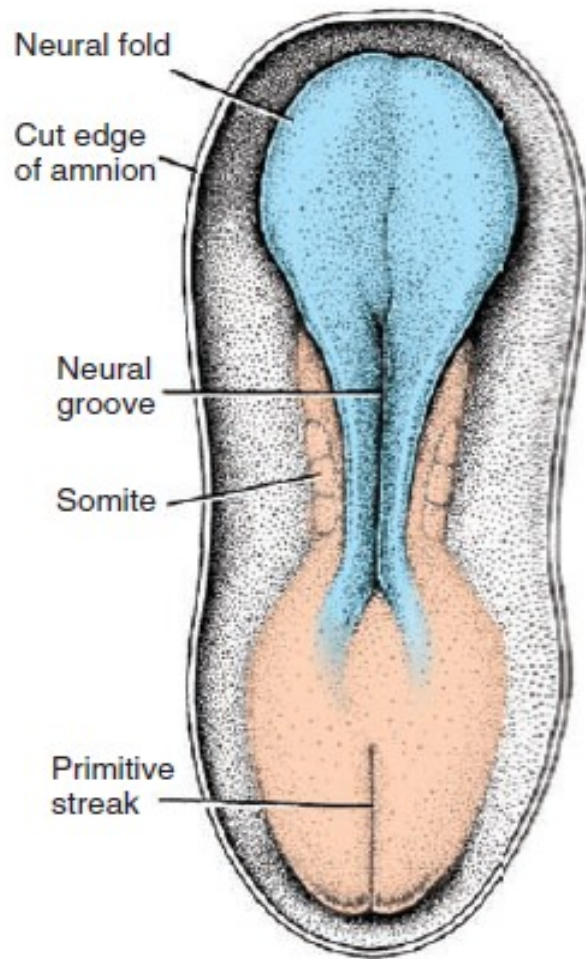
Endoderm

Notochord

Week 4 Neurulation

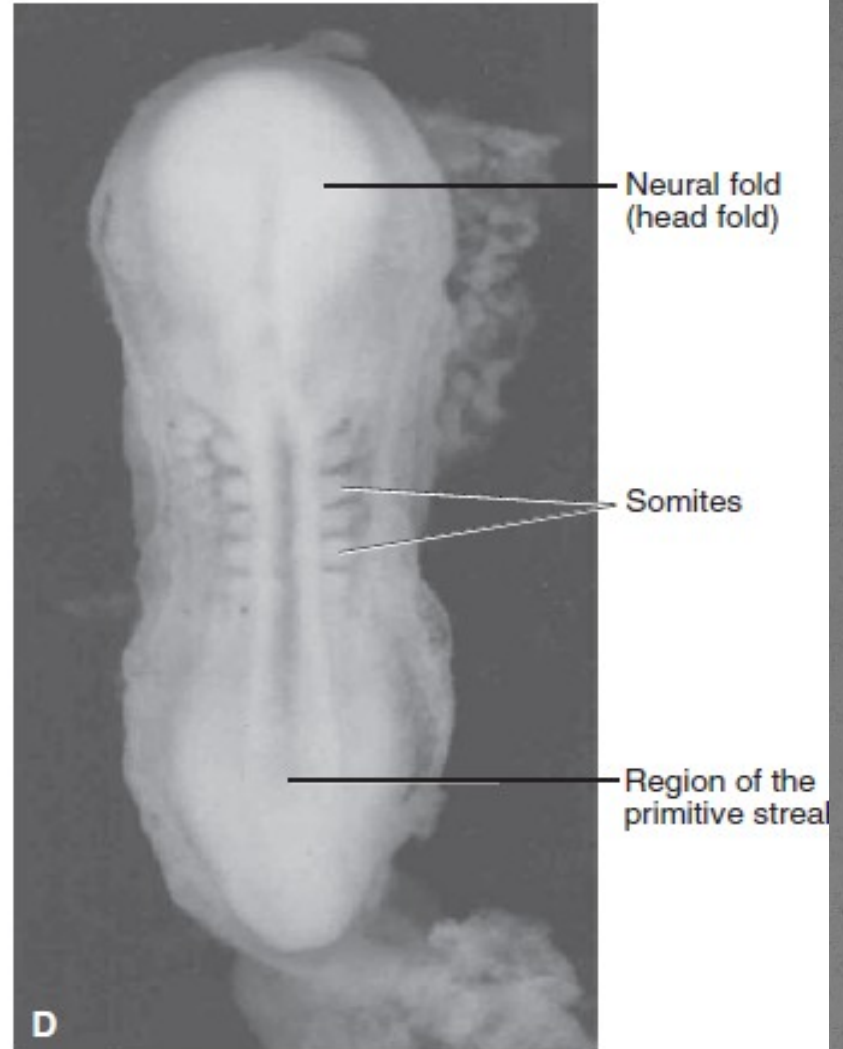
- Thickening of the **ectoderm** leads to the development of the **neural plate**.
- The **neural groove** begins to develop at 20 days.
- At 22 days the neural groove has closed in the middle to form the **neural tube**.
- It remains open at either end.
- The anterior opening or neuropore closes day 25-26 and the posterior neuropore day 27-28.
- A 27-day embryo should have a completely closed neural tube.
- The heart is visible and has already started to beat

19 days



C

20 days



D

20 days

Figure 6.2 **A.** Dorsal view of a late presomite embryo (approximately 19 days). The amnion has been removed, and the neural plate is clearly visible. **B.** Dorsal view of a human embryo at 19 days. **C.** Dorsal view of an embryo at approximately 20 days showing somites and formation of the neural groove and neural folds. **D.** Dorsal view of a human embryo at 20 days.

Weeks 5-8 Organogenic Period

- At 5th week, **Organ system** development is well underway.
- This is a critical time for development of the **heart, limbs, eyes, upper lip, intestines**
- At 7th week the embryo has completed much of its **organogenesis**.
- 8th week, Organogenesis is largely complete , development of **the external genitalia** is still incomplete.
- The **brain** is about to start an 8-week period of **massive neuronal cell formation** for the **cerebral cortex**.

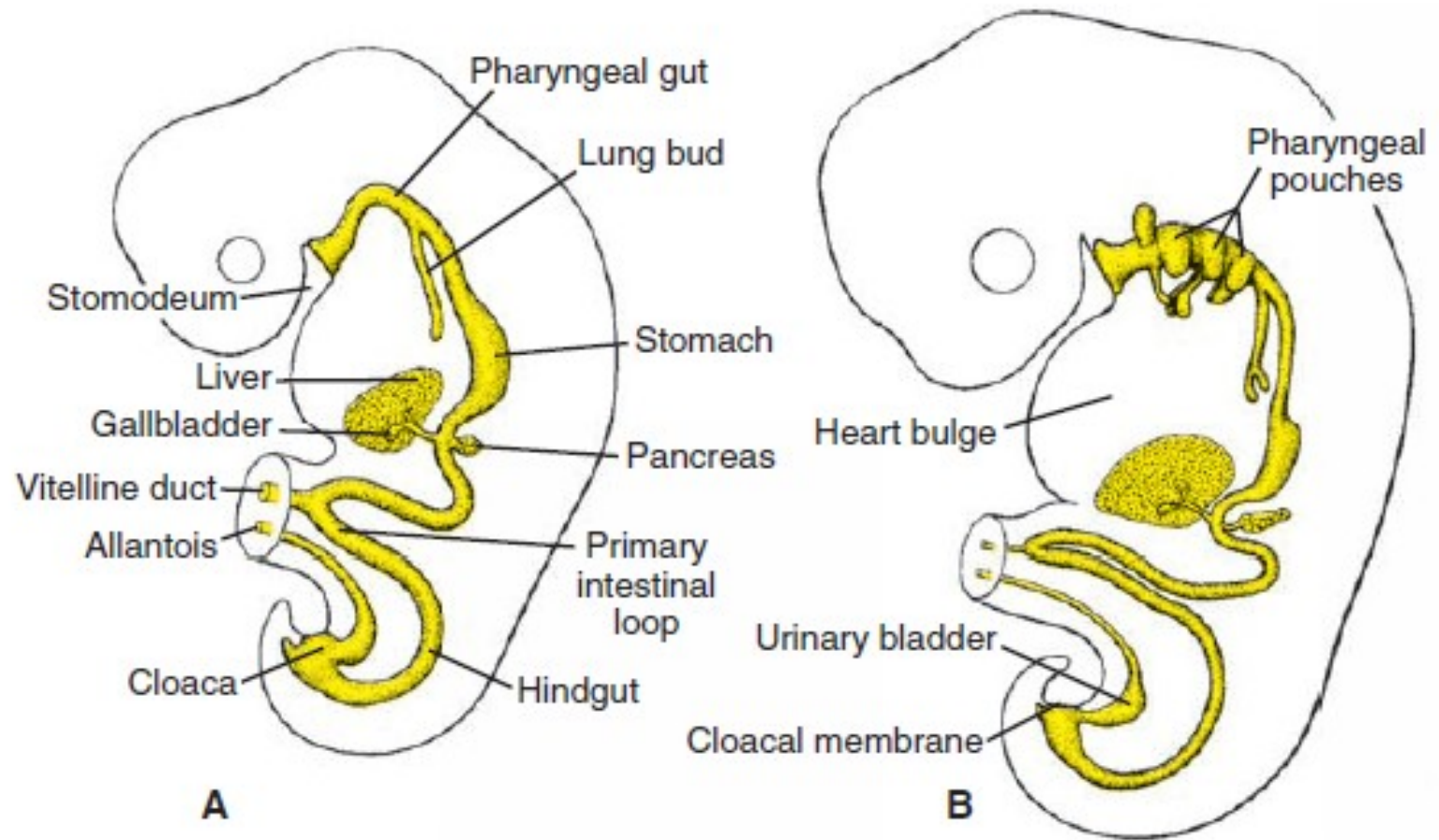


Figure 6.19 Sagittal sections through embryos showing derivatives of the endodermal germ layer. **A.** Pharyngeal pouches, epithelial lining of the lung buds and trachea, liver, gallbladder, and pancreas. **B.** The urinary bladder is derived from the cloaca and, at this stage of development, is in open connection with the allantois.

Week 9-38 Fetal Period

- An 8-week fetus is about 4 cm in length (crown-heel), about 4 cm in length (crown-heel),
- The newborn is about 50 cm (crown-heel)
- At 10th week, Fetal heart beat can be monitored at this stage
- At 13th week, the fetus is surrounded by about 100 ml of amniotic fluid.
- At 16th week, about 14cm long and 190g
- Sex of the fetus can usually be determined at 16 to 18 wk.



Figure 8.3 An 11-week fetus. The umbilical cord still shows a swelling at its base, caused by herniated intestinal loops. The skull of this fetus lacks the normal smooth contours. Fingers and toes are well developed.

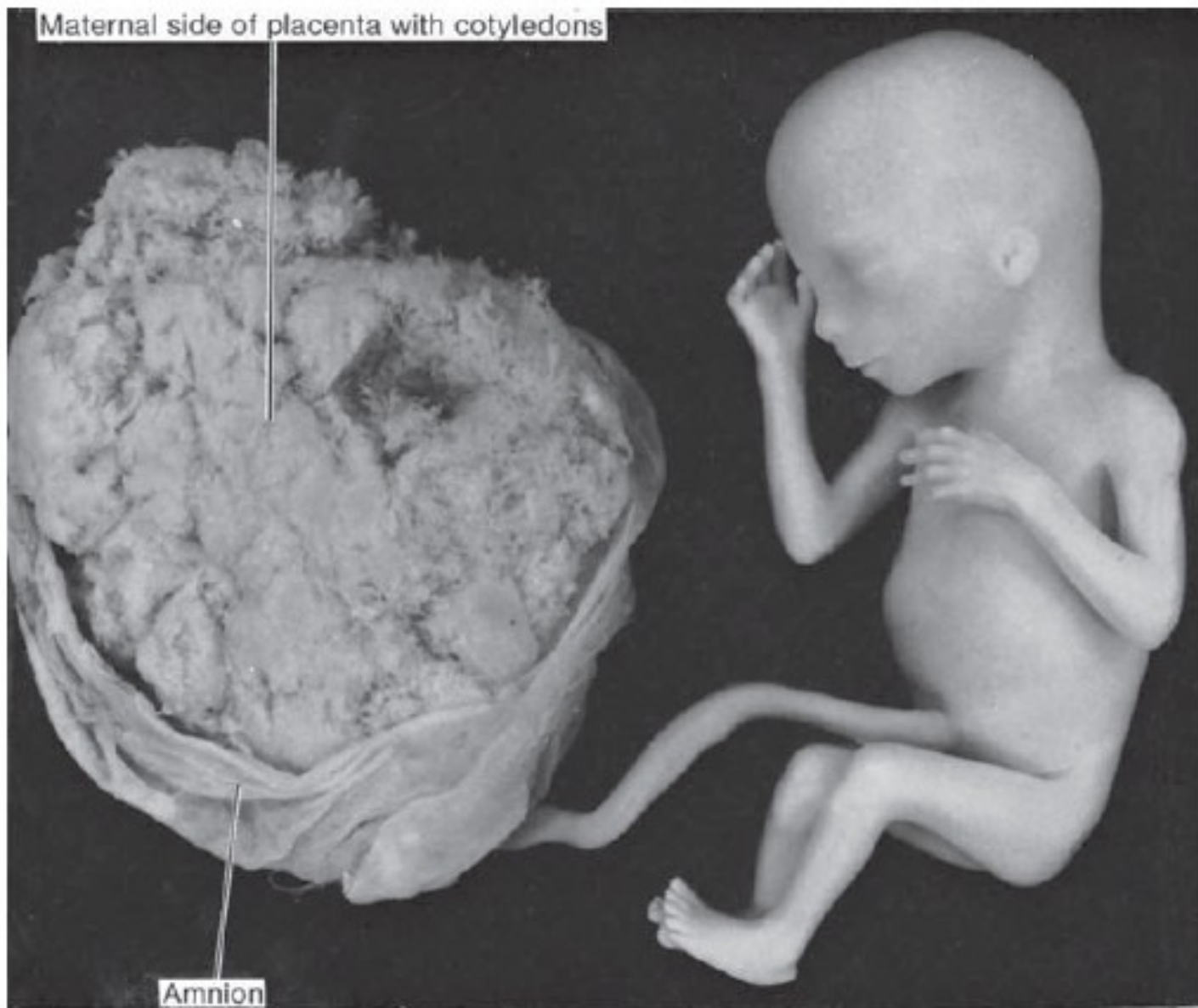


Figure 8.5 An 18-week fetus connected to the placenta by its umbilical cord. The skin of the fetus is thin because of lack of subcutaneous fat. Note the placenta with its cotyledons and the amnion.

- At 24 week, about 23cm and 760g
- 90% of premature babies born who weigh 800 g or more will survive.
- Eyes reopened at about 26 weeks,
- At about 30 weeks skin becomes thicker and subcutaneous fat appears
- 38 weeks term, about 36cm, weight about 3500g

Thank You!