EMBRYOLOGY
Module Foundation

SMART VISION INSTITUTE

2029

نبراس Nebras

في البداية نتمنى أن نكون قدمنا لكم ما يفيدكم و تتمنوه و نسألكم الدعاء لكل من كتب و أعاد صياغة هذا المحتوى و دققه ..

بشكل مباشر أو غير مباشر ...

نبراس

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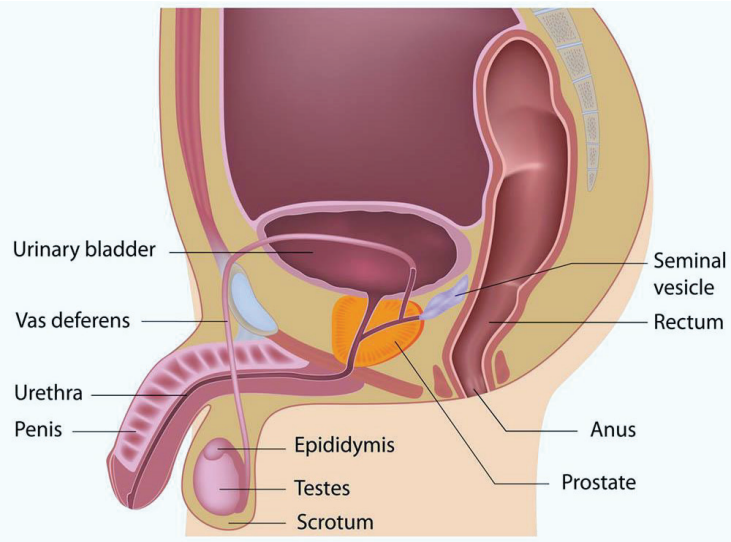
Index

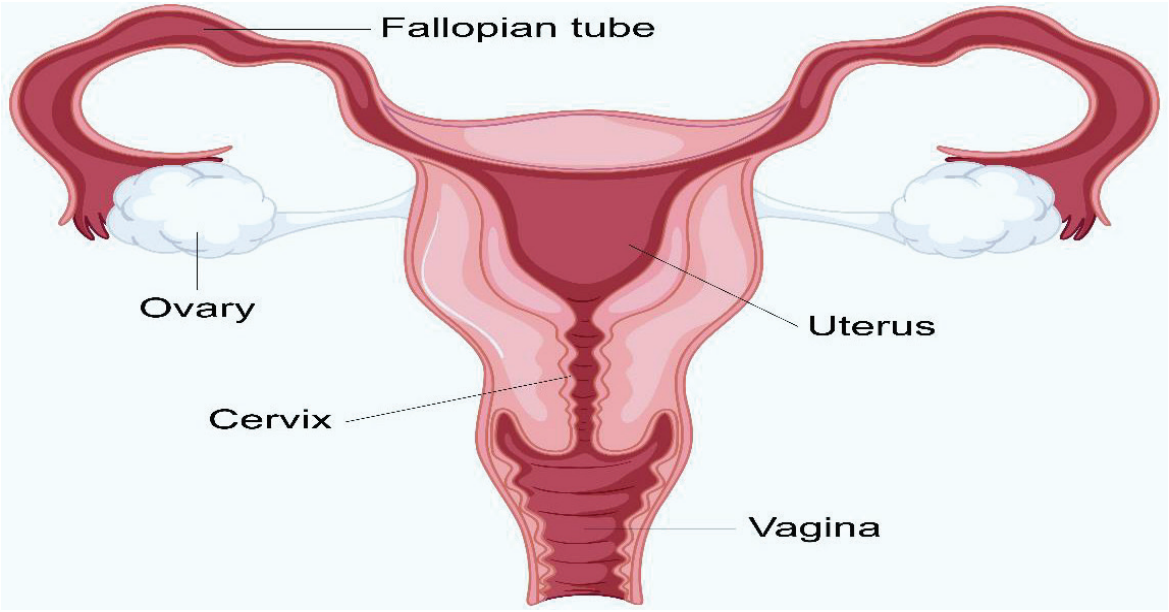
Reproductive organs And Germ cells

- Human development starts at fertilization.
- Fertilization is the process by which the spermatozoon (a male gamete) and the oocyte (a female gamete) unites to give a single cell; the zygote.
- The spermatozoon develops in the testis and the ovum develops in the ovary.

Male reproductive system:



Female reproductive system:



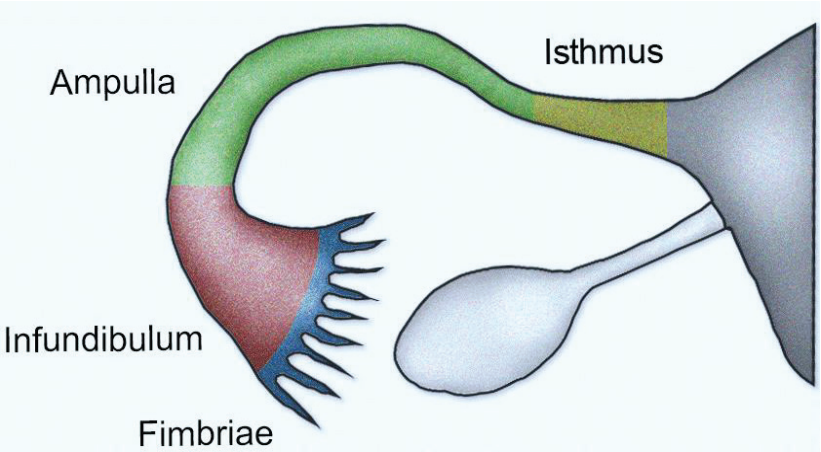
First week development

A. Fertilization التلقيح

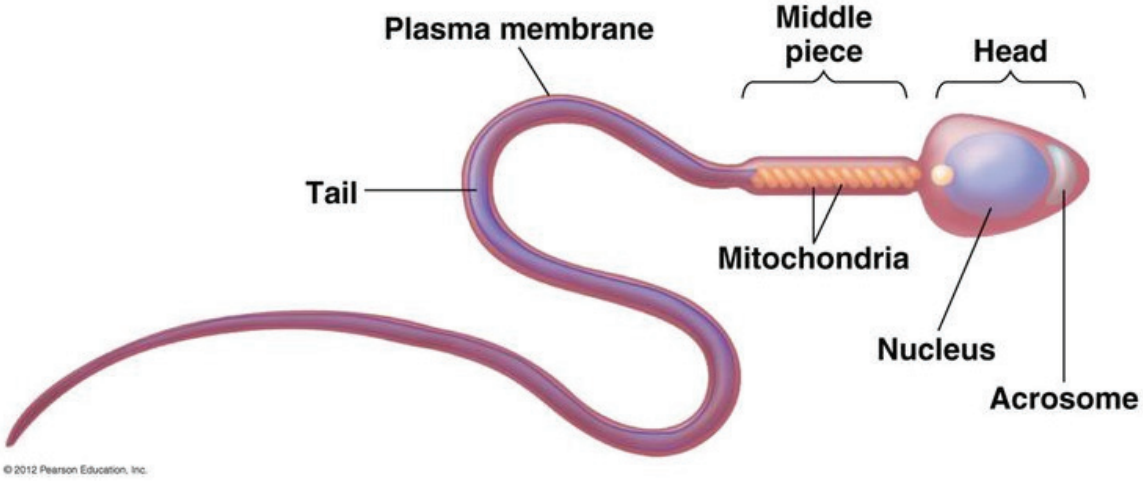
- **Definition:** It is the process by which mature sperm from the male and mature ovum of the female meet and fuse forming the zygote
- **Site:** At the ampullary part of the uterine tube (Fallopian tube)

  Due to:

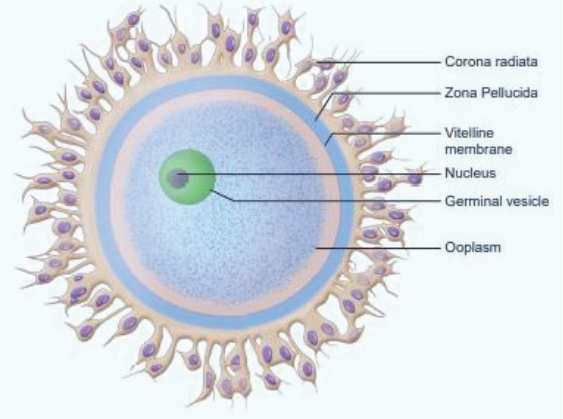
  1. It is close to the ovary
  2. It is the widest part of the uterine tube



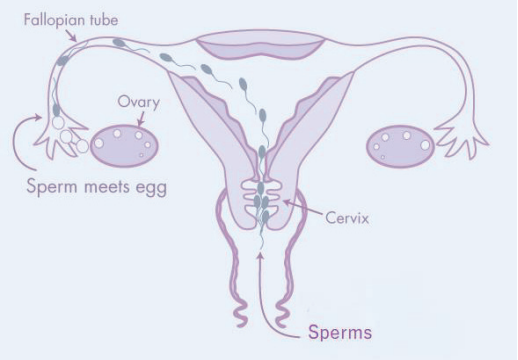
- **Shape of mature sperm:**
  - It is a freely, actively motile cell consisting of: head, neck, middle piece and tail.
  - The head has an acrosome covered with plasma membrane, and contains the nucleus which has 22 chromosomes + Y or X chromosomes.



- **Shape of mature ovum:**
  - It is a large oval cell, its nucleus containing 23 chromosomes (22 chromosome + X chromosome)
  - It has two membranes; the inner thin one is the vitelline membrane and the outer one is the zona pellucida (acellular glycoprotein material).
  - The corona radiata is two or three layers of cells surrounding the zona pellucida.



- **How the sperms reach the site of fertilization:**
  1. By movement of its tail.
  2. By movement of uterine cilia.
  3. By chemoattraction.

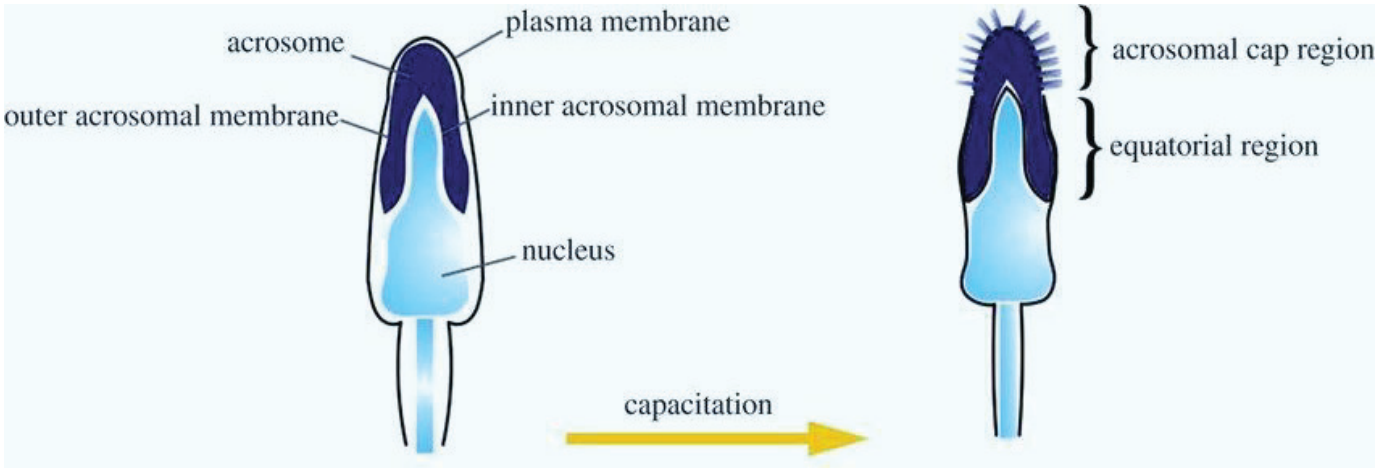


- **How the mature ovum reaches the site of fertilization:**
  1. Capture the fimbria of uterine tube
  2. By muscular contraction of uterine tube (peristalsis).

- **Before the sperm fertilize the oocyte:**

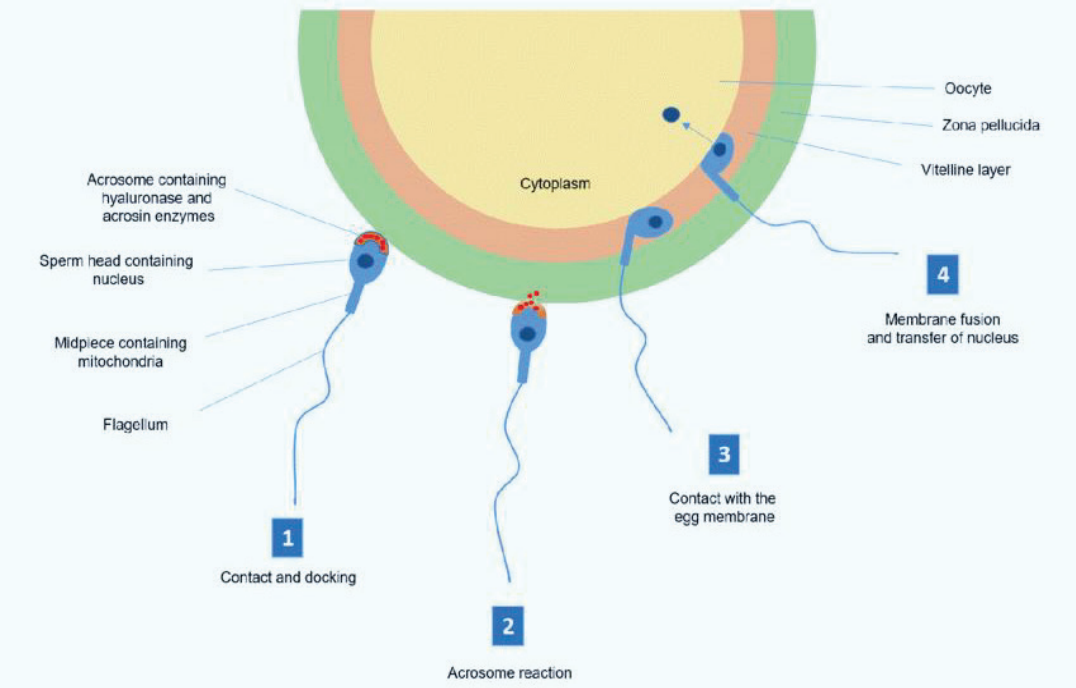
  The mature sperms undergo two processes:

  a. Capacitation:
  - It is the process by means of which the glycoprotein coat is removed from the plasma membrane covers the head of the sperm.
  - Only the capacitated sperm can penetrate the corona radiata.



b. Acrosome reaction:

- It occurs after capacitation.
- The sperm acrosome releases proteolytic enzymes as acrosine, and hyaluronidase to penetrate the zona pellucida



Results of fertilization

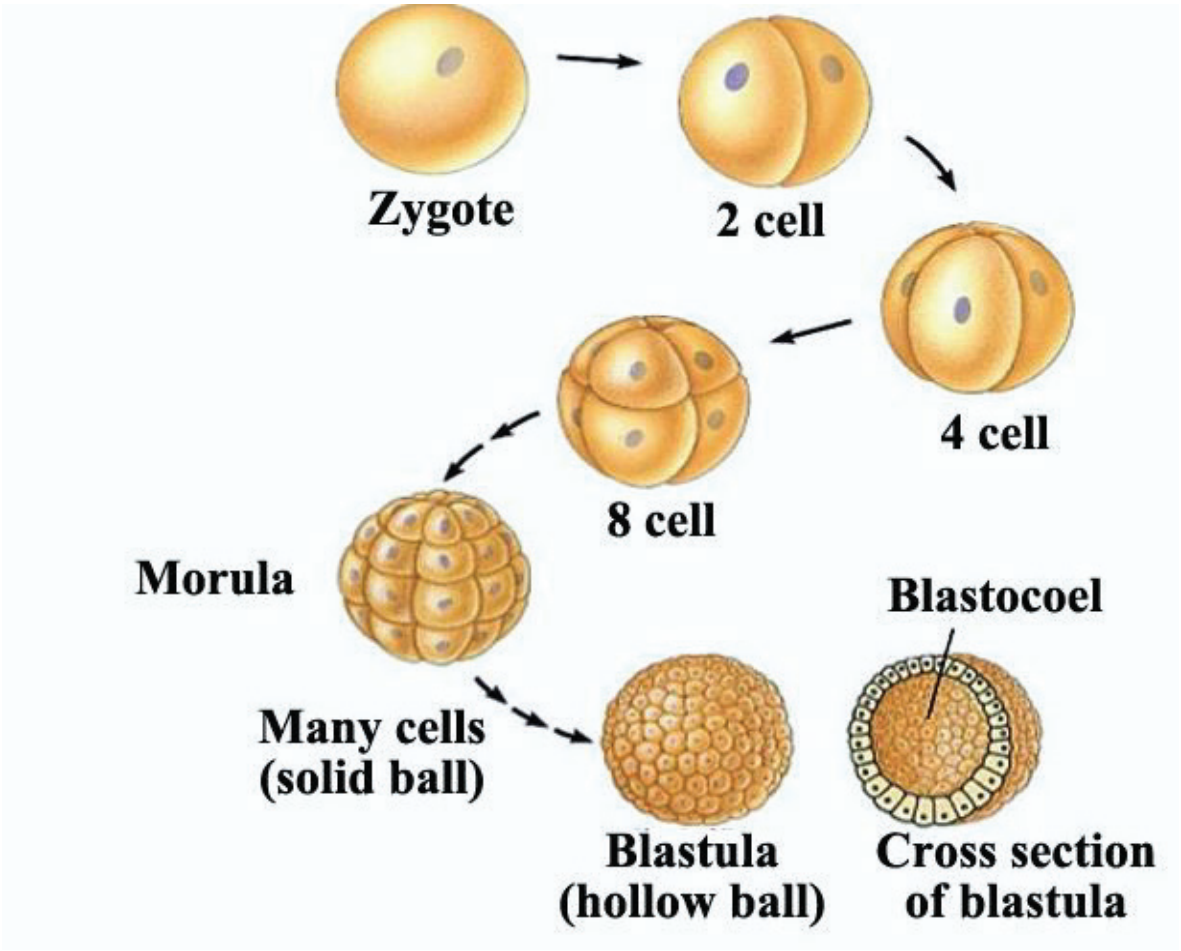
1. Restoration of the diploid number of chromosomes (46).
2. Determination of the chromosomal sex of the embryo
   - Fertilization of the ovum (22X) with an X-bearing sperm (22 X) produces a female embryo (44, XX)
   - Fertilization of the ovum with a Y-bearing sperm (+22Y) produces a male embryo (44, XY).
3. Initiation of cleavage

B. Cleavage الانقسام

- **Definition:**
  - Fragmentation of the zygote by repeated mitotic divisions, resulting into a rapid increase in the number of cells.
  - The resulting daughter cells are smaller than the parent cells, and called blastomeres.
- **Site:**

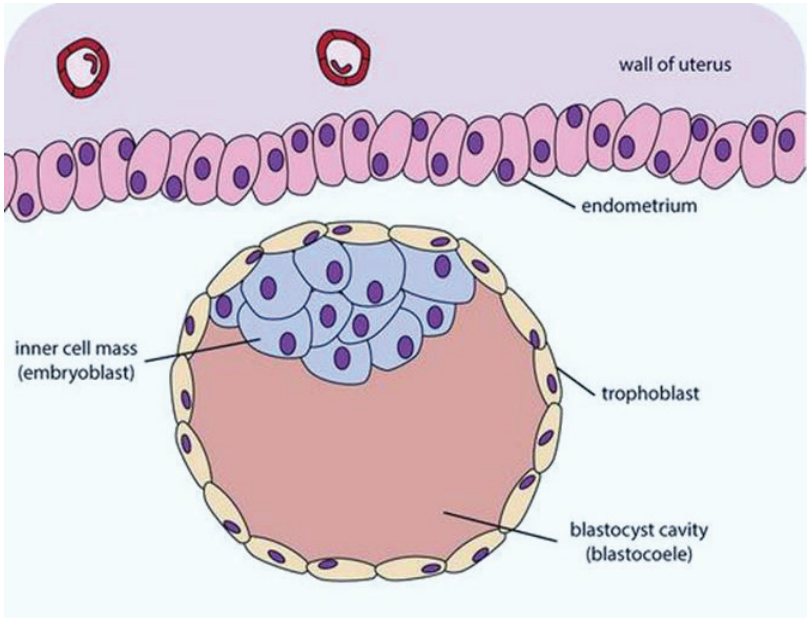
  Medial to the ampulla of the uterine tube (Fallopian tube)
- **Stages of cleavage:**

  a. Morula stage:
  - About 30 hours after fertilization, the zygote divides into 2 cells (blastomeres),
  - After 40 hours it divides into 4 blastomeres
  - After 3 days of fertilization, it reaches Twelve (12) blastomeres
  - At the fourth day (96 hours) it reaches 16 blastomeres
  - The developing embryo of 12- 16 blastomeres is called morula (like a mulberry tree شجره التوت) that enters the uterus nearly 3 days after fertilization.



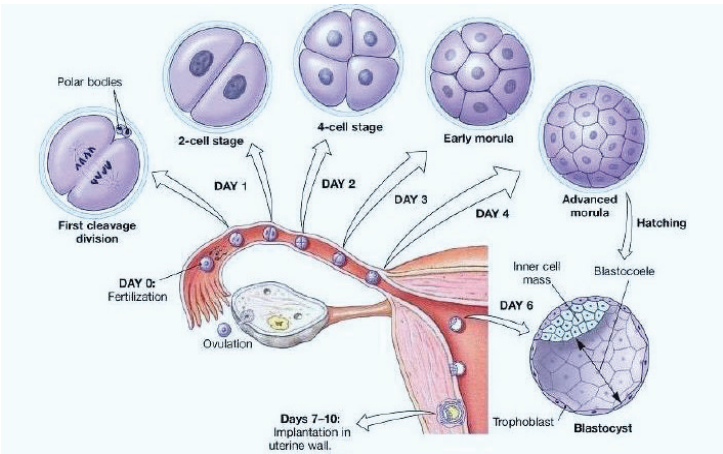
b. Blastocyst formation:

- As the morula enters the uterus, fluid from the uterine cavity penetrates through the zona pellucida and coalesces to form a single cavity (the blastocele) and the embryo is called blastocyst.
- The blastocele divides the blastomeres into inner cell mass which will form the embryo proper.
- The surrounding cells of the periphery form the outer cell mass which will form the trophoblast that will form the fetal part of the placenta (trophe = nutrition).
- The cells of the inner cell mass are now called the embryoblast and are located at one pole of the blastocyst.
- The zona pellucida disappears immediately before implantation.



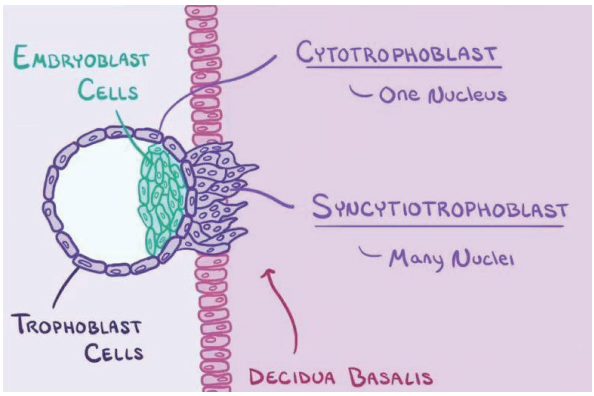
Clinical application:

- Embryonic stem cells (ES cells) are derived from the inner cell mass. These cells can give rise to any type of tissues of the embryo except the trophoblast, so they are called pluripotent cells.

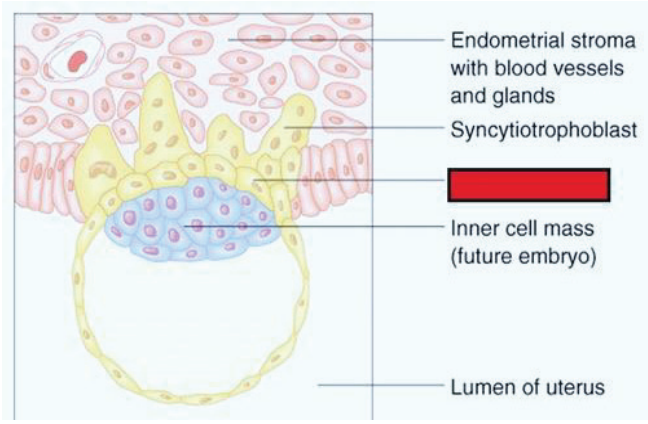


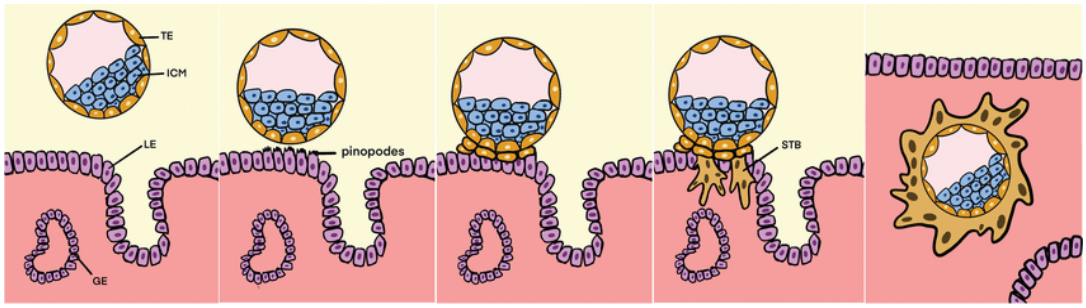
C. Impanation غرس

- **Definition:** It means penetration of the blastocyst into the superficial (compact) layer of the uterine endometrium
- **Mechanism of implantation:**
  - While floating freely in the uterus, the embryo gets nourishment from secretions of the uterine glands.
  - The zona pellucida disappears to allow implantation.
  - About 6 days after fertilization, the blastocyst at the inner cell mass side (embryonic pole) attaches to the endometrium.
  - **The trophoblast proliferates rapidly and becomes differentiated into two layers:**
    A. An inner cellular layer of cytotrophoblast.
    B. An outer multinucleated protoplasmic mass with no cell membrane called syncytiotrophoblast.
  - The syncytiotrophoblast forms finger like processes that extend into the endometrium of the uterus



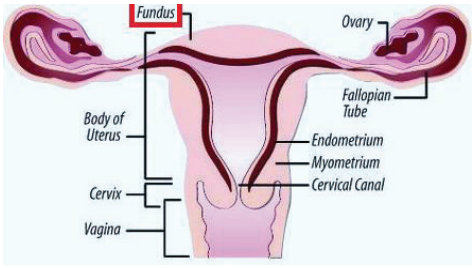
  - By the end of the first week, the blastocyst is superficially implanted in the compact layer of the endometrium.
  - The syncytiotrophoblast at the embryonic pole expands quickly, it produces enzymes that erode the uterine maternal tissues, so enabling the blastocyst to burrow into the endometrium. This implanted blastocyst gets its nourishment from the eroded maternal uterine tissues.

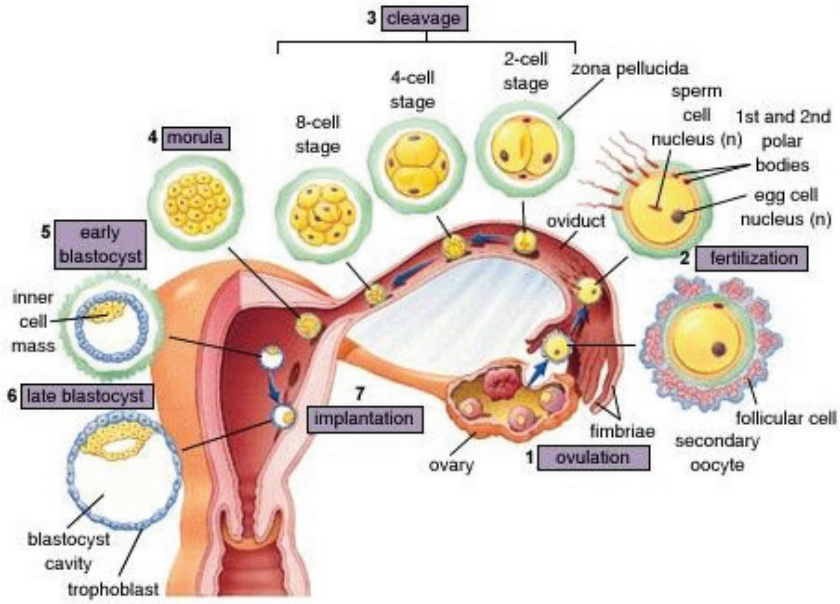




- Seven days after fertilization, a layer of cells; the hypoblast appears on the surface of the inner cell mass facing the blastocele.
- After the blastocyst is completely implanted, the penetration defect in the endometrium is closed by a fibrin clot, then repair of the surface epithelium takes place.
- After complete blastocyst implantation, the endometrium is called "decidua"

- **Normal site of implantation:**
  - The endometrium of the posterior or anterior wall of the fundus of the uterus in or near the middle line.





- **Time of implantation:**
  - Implantation occurs at the 6th day after fertilization and is completed about the 11th day.
- **Function of zona pellucida:**
  1. Allows penetration of the ovum by single sperm and prevents others by changing its chemical nature after entrance of the first sperm.
  2. Prevents adhesion of the developing blastomeres to uterine tube mucosa.
- **Abnormal implantation (Ectopic pregnancy):**
  - It is implantation of the blastocyst in any place other than the normal site
  - It might result in death of the embryo or early abortion (loss of embryo) with severe internal hemorrhage.

- **Abnormal sites of implantation:**

1. Uterine ectopic pregnancy:

a. At the cornu of the uterus (the site of attachment of the uterine tube) leading to early abortion.

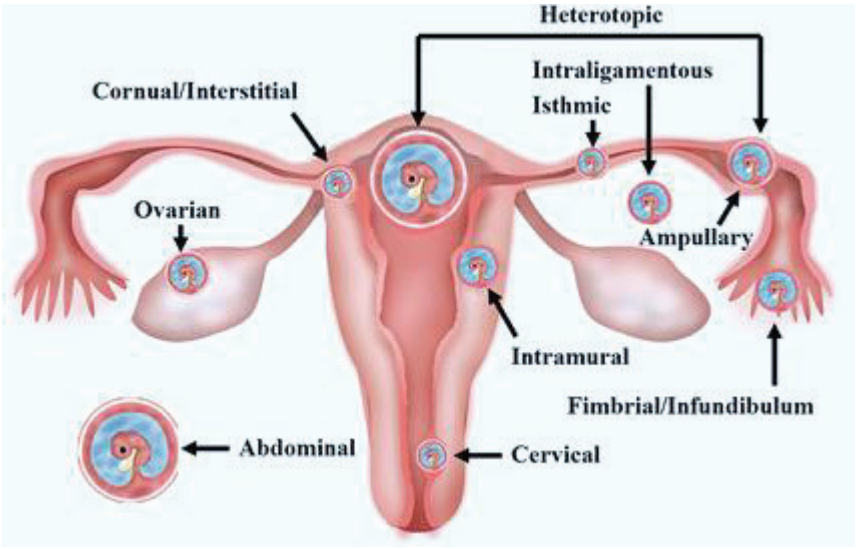
b. At the lower uterine segment or cervix leading to placenta previa

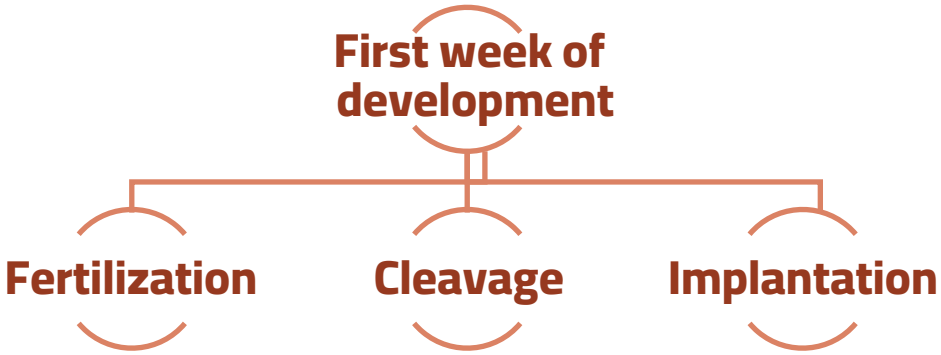
2. Extra uterine ectopic pregnancy:

a. The commonest site is in the Fallopian tube leading to tubal pregnancy that leads to early abortion or tubal rupture with severe internal hemorrhage.

b. Ovary (ovarian pregnancy).

c. Peritoneum of Douglas pouch (abdominal pregnancy), broad ligament of the uterus or omentum of the stomach (rare)





Placenta previa

- **Definition:**
  - Implantation of the blastocyst in the lower segment of the uterus close to the internal os, Thus the placenta will precede the fetus at delivery. (Normally, the fetus is the lowermost and fills the lower segment).
  - Previa = at the front of the fetus.
- **Types of the placenta previa**

1. Placenta previa parietalis:

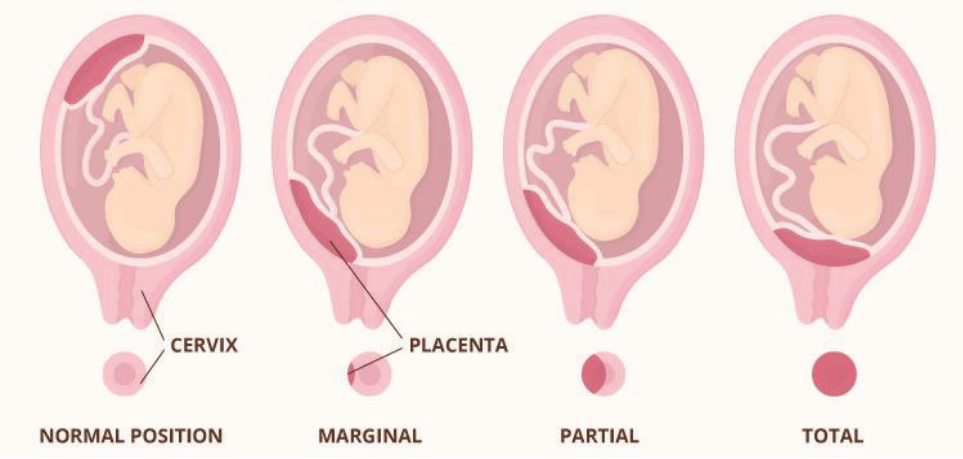
- The placenta lies in the lower segment but does not encroach on the internal os of the cervical canal.

2. Placenta previa marginalis:

- The placenta lies in the lower segment and covers partially the internal os of the cervical canal.
- During labor, the placenta is shifted upwards away from the internal os and becomes as placenta previa lateralis. (Paritalis)

3. Placenta previa centralis:

- The placenta lies in the lower segment and completely covers the internal os of the cervical canal.
- During labor, the placenta occludes the internal os (doesn't shift away upwards) and presents from the cervix.



- **The main complications of placenta previa:**

1. Severe antepartum hemorrhage (bleeding before birth).
2. Fetus malposition.

Decidua

- **Definition:**
  - The compact layer of the endometrium after implantation of the blastocyst.

- **Types of the decidua:**

1. Decidua basalis:

- It is the part of endometrium lying at the base of the implanted blastocyst, between it and the myometrium of the uterus.
- It will form the maternal origin of the placenta.

2. Decidua capsularis:

- It is the part of endometrium covering the surface of the implanted blastocyst, between the blastocyst and the uterine cavity.

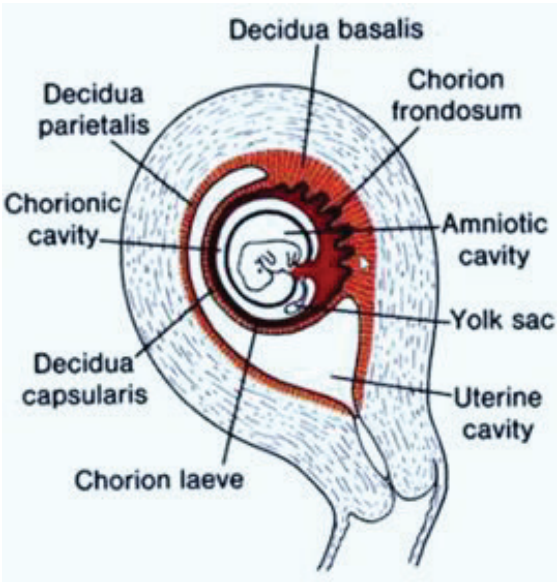
3. Decidua parietalis:

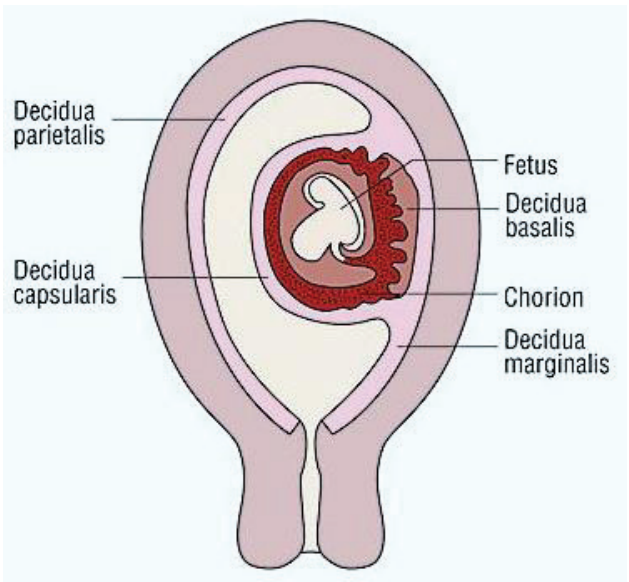
- It is the part of endometrium lining the rest of the uterine cavity.

4. Decidua marginalis:

- It is the part of endometrium lying at the junction between decidua capsularis and parietalis (It lies at the margins of the implanted blastocyst).

The last three types of decidua will ultimately fuse and degenerate with the advance of pregnancy due to growth of the fetus





Second week development

(The Bilaminar Germ Disc)

- **Changes occurring during the second week of development:**

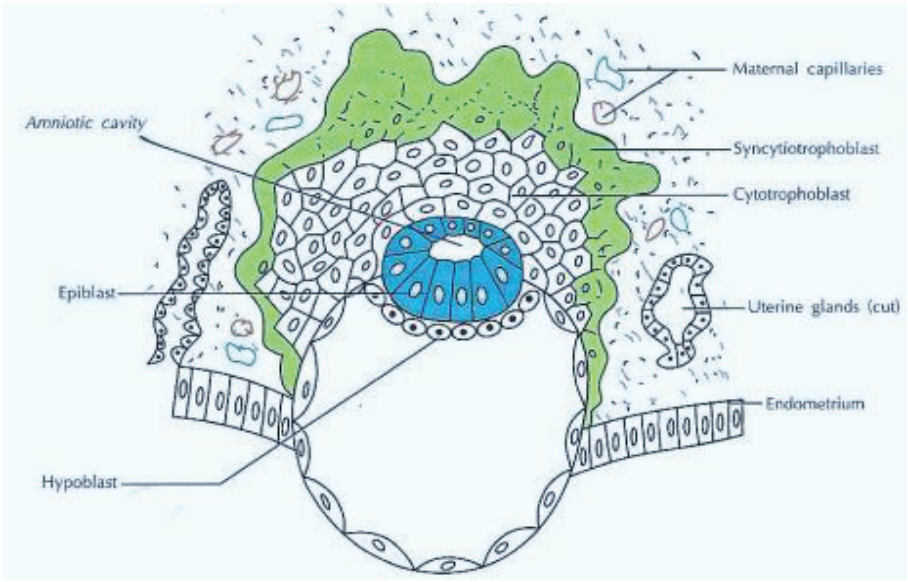
1. Further differentiation of the Trophoblast:

- **The trophoblast is formed of two layers:**
  a. Inner layer of mononucleated cells called the cytotrophoblast.
  b. Outer layer of syncytiotrophoblast, it is formed by migration of cytotrophoblasts after losing their cell membrane.
- Syncytiotrophoblast will form finger like processes called villi, they erode the maternal uterine tissues and vessels, leads to formation of spaces between them filled with maternal blood, these spaces is called lacuna, The lacuna coalesce together to form intervillous space.

2. Formation of the bilaminar germ disc:

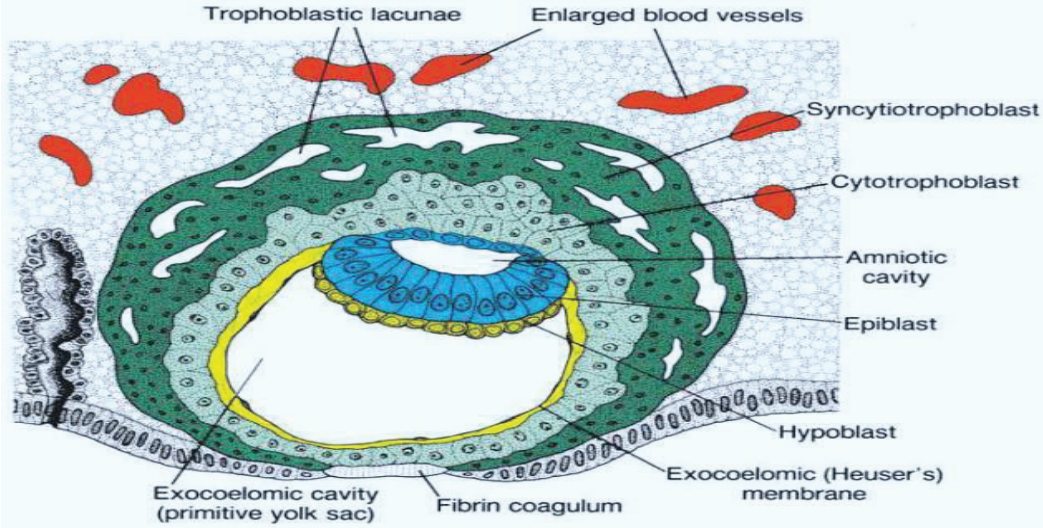
- **Cells of the inner cell mass differentiate into two layers:**
  a. Layer of small, cuboidal cells adjacent to the blastocyst cavity called the hypoblast (endodermal) layer.
  b. Layer of tall columnar epithelium adjacent to the amniotic cavity, called the epiblast (ectodermal) layer.

The cells of these two germ layers form the bilaminar germ disc (embryo).



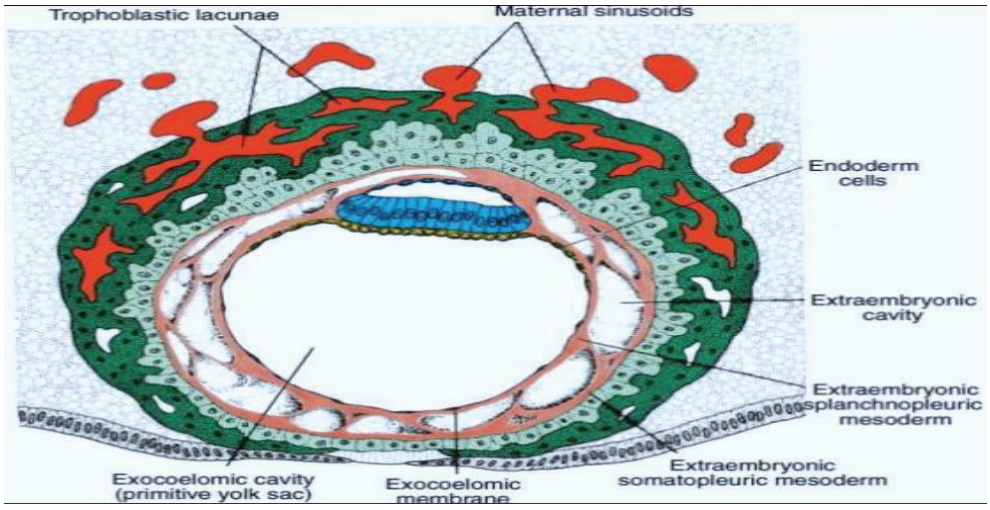
3. Formation of the amniotic and yolk sac cavities:

- Some vacuoles appear within the epiblast layer (ectodermal layer). They collect together to form a small cavity called the amniotic cavity.
- The cells of the epiblast (ectoderm) adjacent to the cytotrophoblast are called the amnioblasts.
- The amnioblasts form the roof of the amniotic cavity and the ectodermal layer of the embryonic disc forms the floor of the cavity.
- Another cavity is formed in the ventral aspect of the embryonic disc, called the primitive yolk sac (the exo-coelomic cavity). Its roof is formed of the endodermal layer of the embryonic disc.

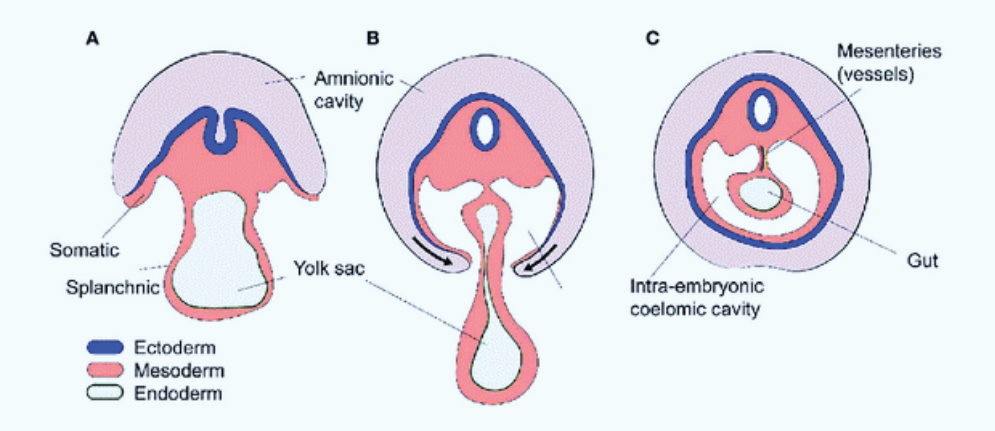


4. Formation of the extra-embryonic mesoderm and extraembryonic coelom

- The endoderm of the wall of the yolk sac gives a new cell called the extra-embryonic (primary) mesoderm which surrounds the amnion, and yolk sac.



- A cavity appears in the extra-embryonic mesoderm called the extra-embryonic coelom (the chorionic cavity).
- **The extraembryonic primary mesoderm is divided into two layers by the extra-embryonic coelom:**
  1. An outer layer lining the trophoblasts and the amnion, called the extra-embryonic somatopleuric mesoderm.
  2. An inner layer covering the yolk sac called the extra-embryonic splanchnopleuric mesoderm.
- The two layers are connected by body stalk.
- The intraembryonic coelom is a space appears in the intraembryonic mesoderm, it is in the shape of an inverted U.



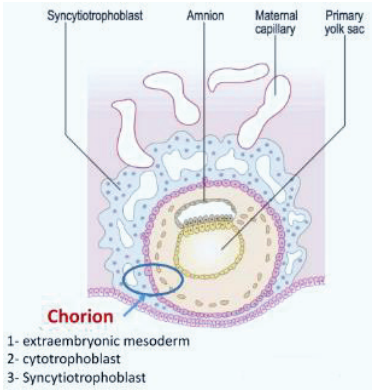
- **It will give rise to:**
  a. **The future pericardial cavity:** at the center of the coelom
  b. **The future pleural cavity:** on either side of pericardial cavity.
  c. **The future peritoneal cavity:** lateral to the pleural cavities on either side and connected to the extraembryonic coelom.

Clinical application

- Syncytiotrophoblast secretes human chorionic gonadotrophin hormone (HCG) which prevents the degeneration of the corpus luteum.
- It also stimulates the production of progesterone from the ovary.
- By the end of the 2nd week, the amount of this hormone will be sufficient to be detected in the maternal blood and urine.
- This is the basis of the pregnancy test.

- **The second week of development is the week of twos:**
  - Trophoblast differentiates into 2 layers, cytotrophoblast & syncytiotrophoblast.
  - Inner cell mass differentiates into 2 layers, epiblast & hypoblast.
  - Primary mesoderm splits into somatopleuric primary mesoderm & splanchno-pleuric primary mesoderm.
  - Starting of formation of the amniotic and yolk sac cavities.

The Chorion



- **The chorion is formed of:**
  1. An outer layer consisting of the two layers of trophoblast.
  2. An inner layer of primary mesoderm (extra-embryonic mesoderm).

The Chorionic Villi

- **Types of the villi according to structure:**

a. Primary villi:

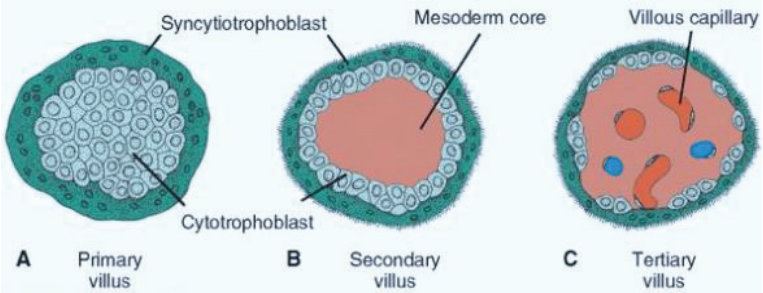
- It is the early strand of trophoblasts.
- **It is formed of:**
  1. An inner cytotrophoblasts
  2. An outer syncytiotrophoblast.
- The blood spaces in between the villi called the intervillous spaces filled with maternal blood.

b. Secondary villi:

- The extra-embryonic mesoderm cells invade the primary villi forming a core inside them.

c. Tertiary villi:

- Umbilical blood vessels are formed in the mesodermal core of the secondary villi.



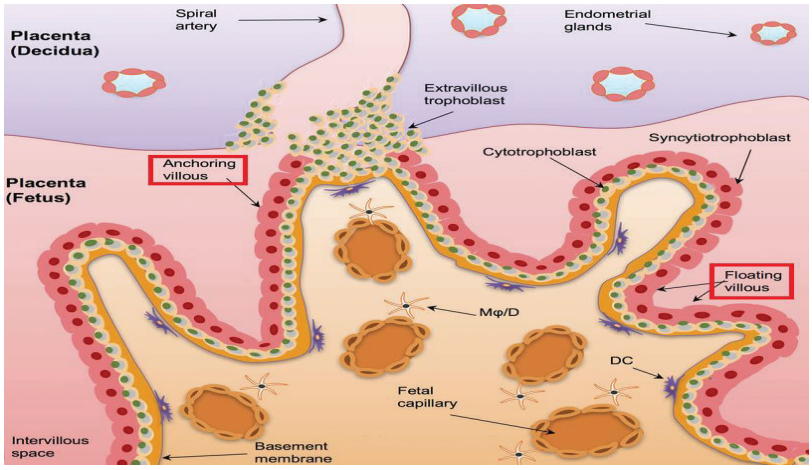
- **Types of villi according to their function:**

1. Anchoring villi:

- They fix the embryonic so they penetrate deeply the decidua basalis of the uterus.

2. Free (Nourishing) villi:

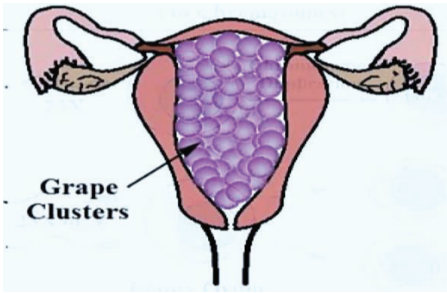
- They are free and do not reach the decidua.
- They extend into the maternal blood of the intervillous spaces for nutrition of the embryo.



- **Abnormalities of chorion:**

a. Hydatidiform mole:

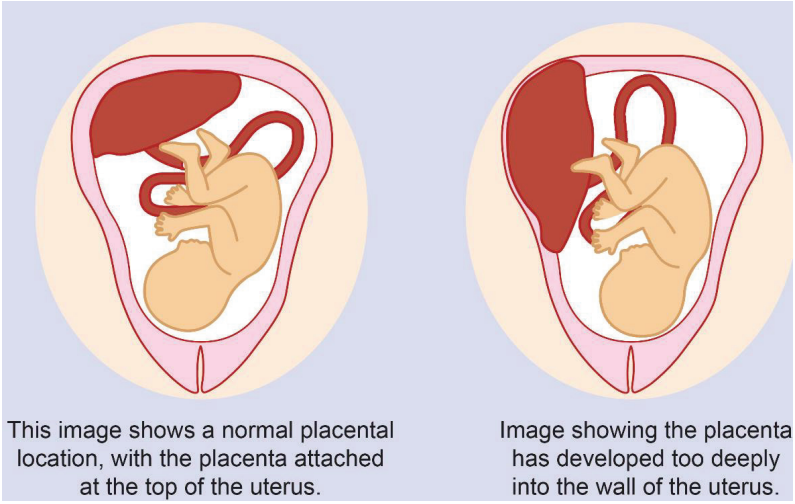
- The trophoblasts develop and form placental membranes but little or no embryonic tissue is present.



b. Choriocarcinoma:

- It is a highly malignant tumor develops on top of hydatidiform mole.

c. Excessive invasion of the uterine wall by the trophoblasts resulting in abnormally adherent placenta accrete



This image shows a normal placental location, with the placenta attached at the top of the uterus.

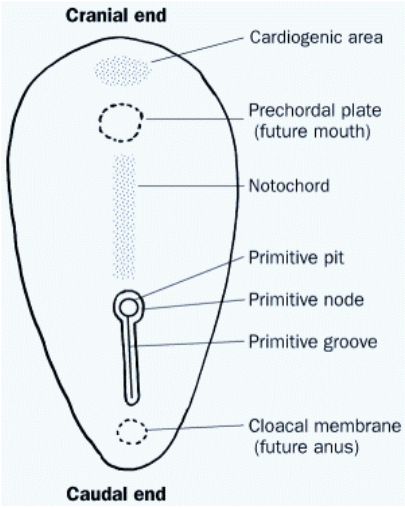
Image showing the placenta has developed too deeply into the wall of the uterus.

Third week Development

(Tri-laminar Germ Disc)

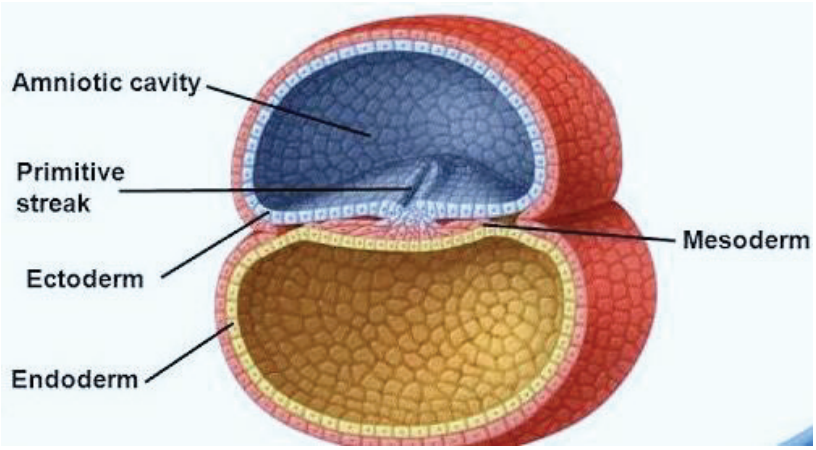
- **Gastrulation:**

(Formation of three germ layers embryo)

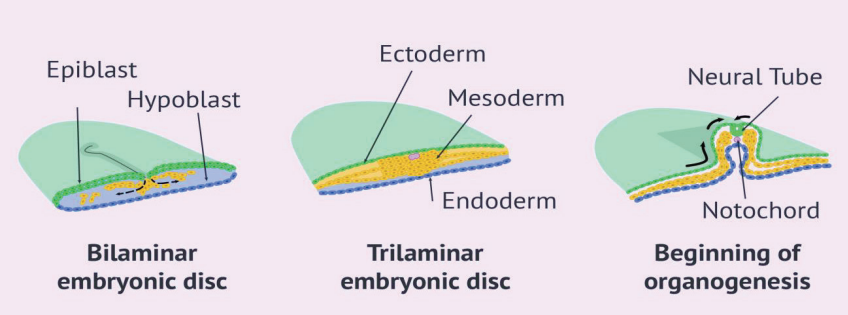


- It is the process by which the bilaminar embryonic disc is converted into a trilaminar embryonic disc.
- Gastrulation is the most characteristic event occurring during the 3rd weak.
- During this period, the embryo is referred to as gastrula.
- Gastrulation begins with formation of a midline groove the on the surface of the caudal part of epiblast of the bilaminar embryonic disc it is called primitive streak
- The cephalic end of this steak is called primitive node. A groove appears at the center of the node called primitive pit.

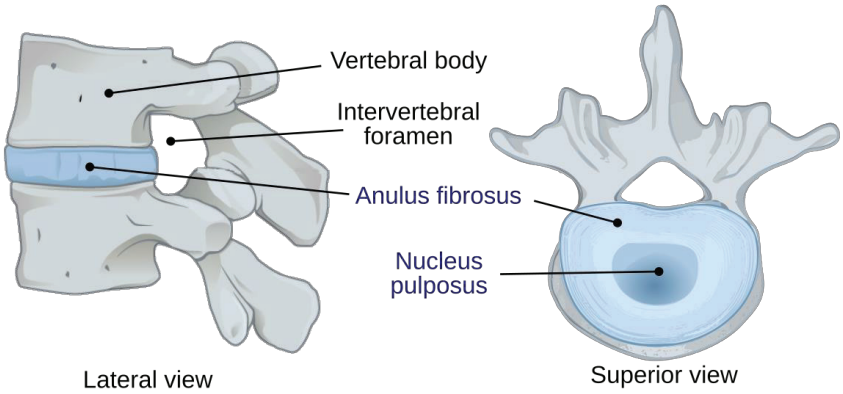
- **Formation of primitive streak (Groove):**
  - Cells of the ectoderm (Epiblast) migrate in the direction of the primitive streak; they slip to under the epiblastic layer through the primitive streak to form The endodermal layer of the embryonic disc
  - Some of invaginated epiblastic cells forms intraembryonic mesoderm
  - thus, the ectoderm or the epiblast is the source of the three germ layers of the embryo
  - The intraembryonic mesoderm migrates in all direction forming a complete layer of cells separating the ectoderm dorsally from the endoderm ventrally (trilaminar embryo).



- **Formation of the notochord:**
  - Some mesenchymal cells migrate cranially from the primitive node and pit (deep to epiblast), forming a median cellular cord; the notochord.



- **Functions of the notochord:**
  1. It forms the axis around which the axial skeleton develops (bones of the head and vertebral column).
  2. It stimulates the overlying ectoderm to form the central nervous system
  3. The notochord degenerates and disappears as the bodies of the vertebrae form.
  - Its remnant is the nucleus pulposus of the intervertebral discs found in between the vertebrae.



- **Clinical application:**
  - Third week of development is a very sensitive period in embryonic development. Many factors such as drugs, alcohol or irradiation to the mother may cause congenital anomalies to her embryo.
  - At the end of the fourth week, the primitive streak shows regressive changes, rapidly shrinks and soon disappears. Sometimes, remnants of the primitive streak persist in sacrococcygeal region. These pluripotent cells proliferate and form tumors known as sacrococcygeal teratomas.

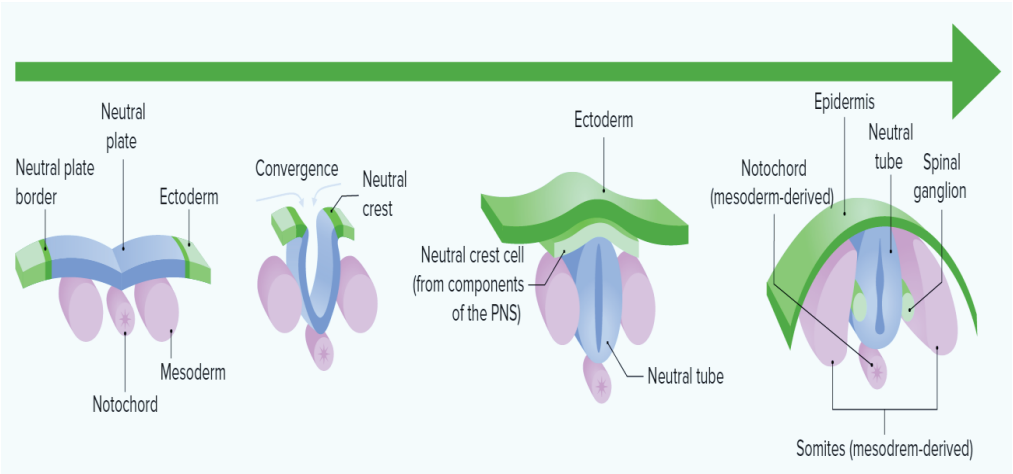
Third to eight weeks

Embryonic period

A. Derivatives of the Ectodermal Germ Layer:

- The ectodermal germ layer gives rise to structures that maintain contact with the outside world as central and peripheral nervous systems, sensory epithelium of ear, nose and eye, epidermis of skin including hair and nails, glands as pituitary, mammary, sebaceous and sweat glands, and the enamel of the teeth.
- **The ectoderm derivatives are divided into:**
  surface derivative, neuroectoderm derivatives.

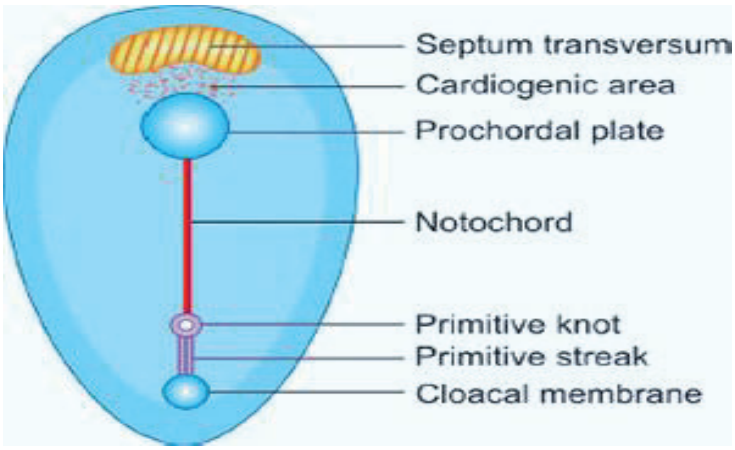
Surface Ectoderm derivative	Neuroectoderm derivative	
	Neural tube	Neural crest
- Epidermis, hair, nails - Cutaneous and mammary glands - Anterior lobe of pituitary gland - Enamel of teeth - Internal ear - Lens of the eye	- Central nervous system - Retina - Pineal body - Posterior lobe of pituitary gland - Iris muscles	- Cranial (V, VII, IX, X) ganglia, - Sensory ganglia and nerves - Medulla of the adrenal gland - Pigment cells of dermis, muscle, connective tissues - Bones of pharyngeal arches - Meninges of the brain and spinal cord - Ensheathing cells of the peripheral nervous system.



B. Derivatives of the Mesodermal Germ Layer

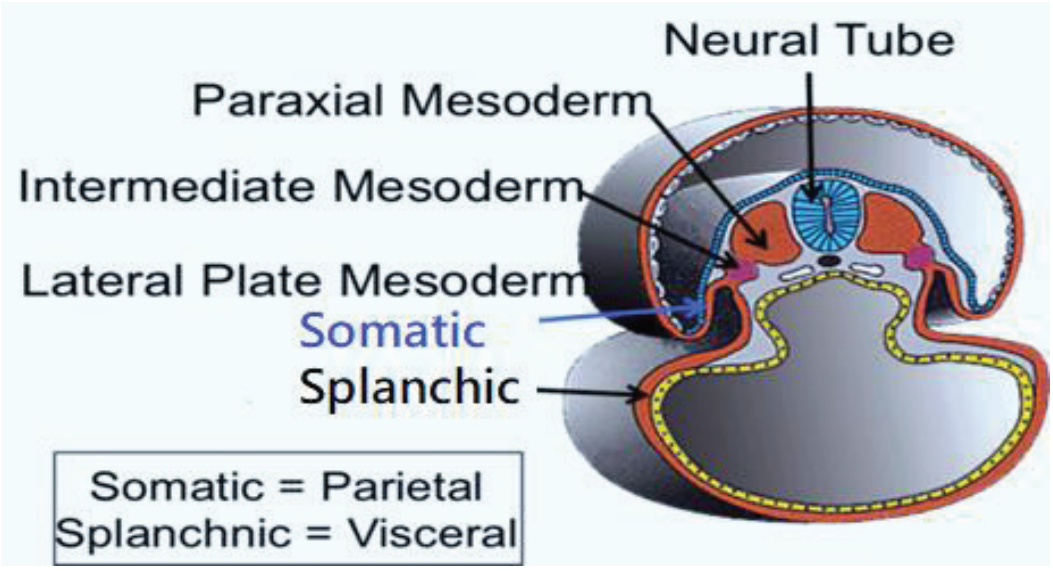
- The ectodermal germ layer gives rise to structures that maintain contact with the outside world as central and peripheral nervous systems, sensory epithelium of ear, nose and eye, epidermis of skin including hair and nails, glands as pituitary, mammary, sebaceous and sweat glands, and the enamel of the teeth.
- **The ectoderm derivatives are divided into:**

surface derivative, neuroectoderm derivatives.



- **The axial mesoderm is absent in the followings:**
  a. **Buccopharyngeal membrane:** it is a defect of axial mesoderm which lies in the midline between the cardiogenic plate and the notochord
  b. **Cloacal membrane:** it is a defect of axial mesoderm which lies at the caudal end of the midline

- **The mesodermal germ layer is divided by a longitudinal groove into three components:**

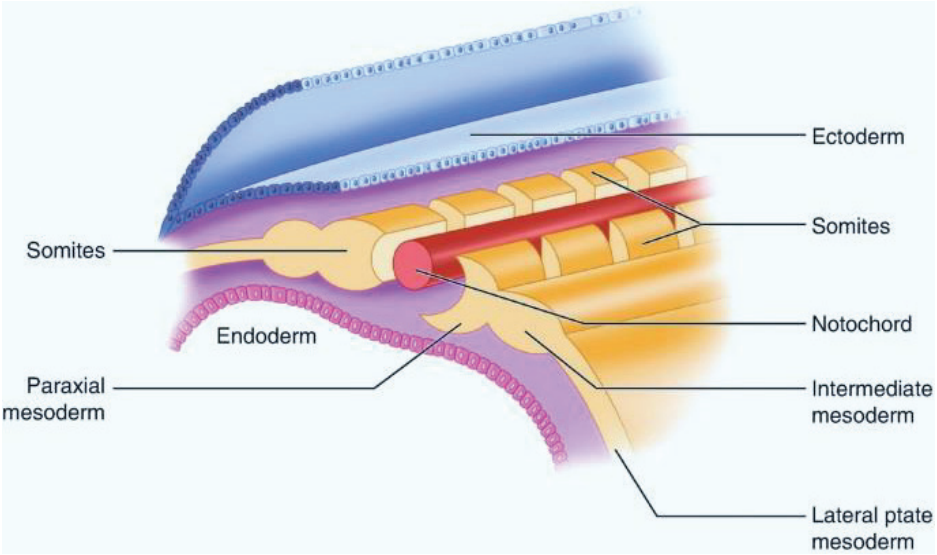


1. The paraxial mesoderm:

- It is the medial part that lies parallel to the notochord
- It is divided by transverse grooves into body blocks called somites or somitomeres (4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 8-10 coccygeal).
- Cells of the ventromedial portion of each somite form the sclerotome which surround the notochord.
- The sclerotomes give the axial skeleton (bones & cartilage).
- The cells of the dorsolateral portion of each somite form the dermomyotome, **which splits into:**

  a. Myotome: that forms muscles.

  b. Dermatome: that forms the skin.
- They give the mesenchyme of the head and the somites in occipital and caudal segments.



2. The intermediate cell mass (nephrogenic cord)

It gives rise to the urinary and genital systems (gonads)

3. The lateral plate of mesoderm

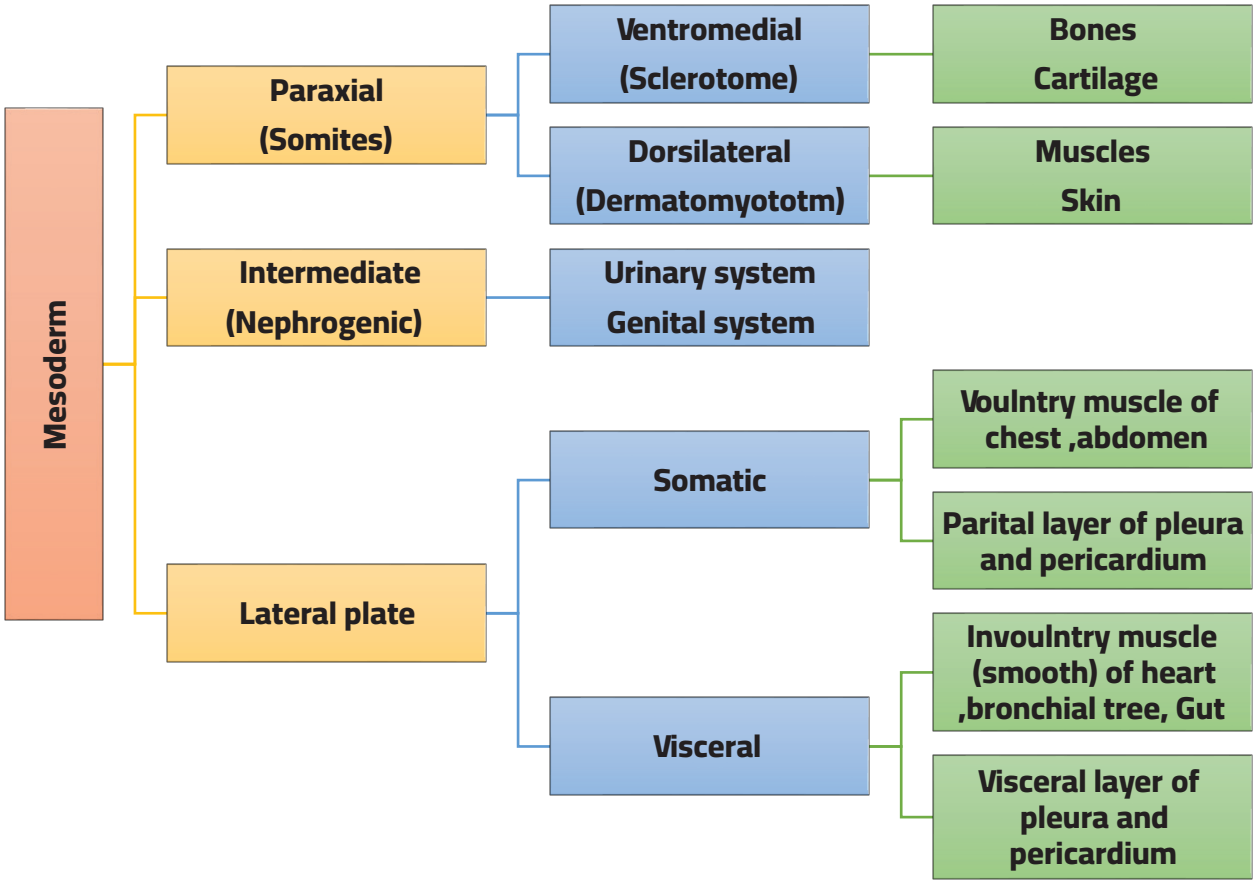
- A series of cavities appear in the lateral plate of mesoderm. They unite forming the intraembryonic coelom.
- The intraembryonic coelom splits the lateral plate of mesoderm into two layers, the somatic and splanchnic layers.

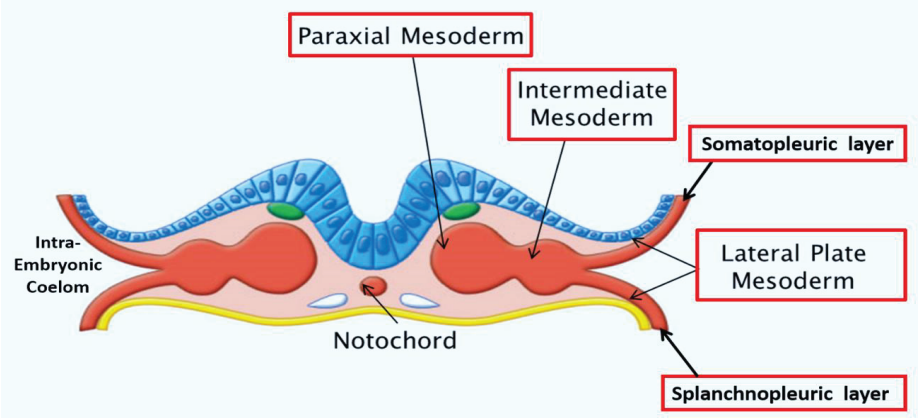
a. The somatic layer:

- It lies next to the ectoderm.
- It forms, with the overlying ectoderm, the somatopleure.
- It will give the voluntary muscles of the chest & abdomen and the parietal layer of pleura & peritoneum.

b. The splanchnic layer:

- It lies next to the endoderm.
- It forms, with the underlying endoderm, the splanchnopleure.
- It will give the smooth or involuntary muscles (heart, bronchial tree & gut) and the visceral layer of pleura & peritoneum.



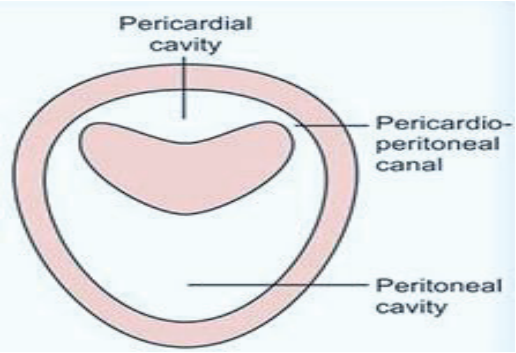


- **The intraembryonic coelom:**
  - It is inverted U shaped space.
  - **It will give rise to:**

i. **The future pericardial cavity:** from its anterior transverse part which lies anterior to the buccopharyngeal membrane.

ii. **The future peritoneal cavity:** from its posterior part.

iii. **The future pleural cavity:** from the lateral communication between the above two cavities.



- A temporary communication between the intraembryonic and extraembryonic coeloms occurs in the stages of growth. This allows fluid to pass to the interior of the fetus for nutrition.
- Cranial to the buccopharyngeal membrane, the mesoderm will form the future heart and septum transversum (future diaphgram)

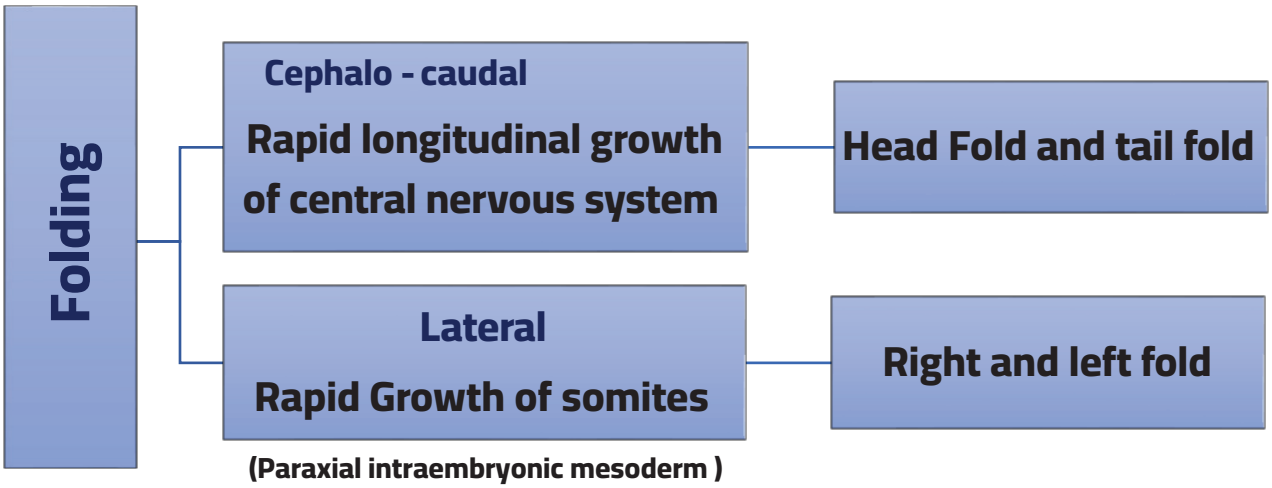
C. Derivatives of the endoderm: (EPITHELIAL)

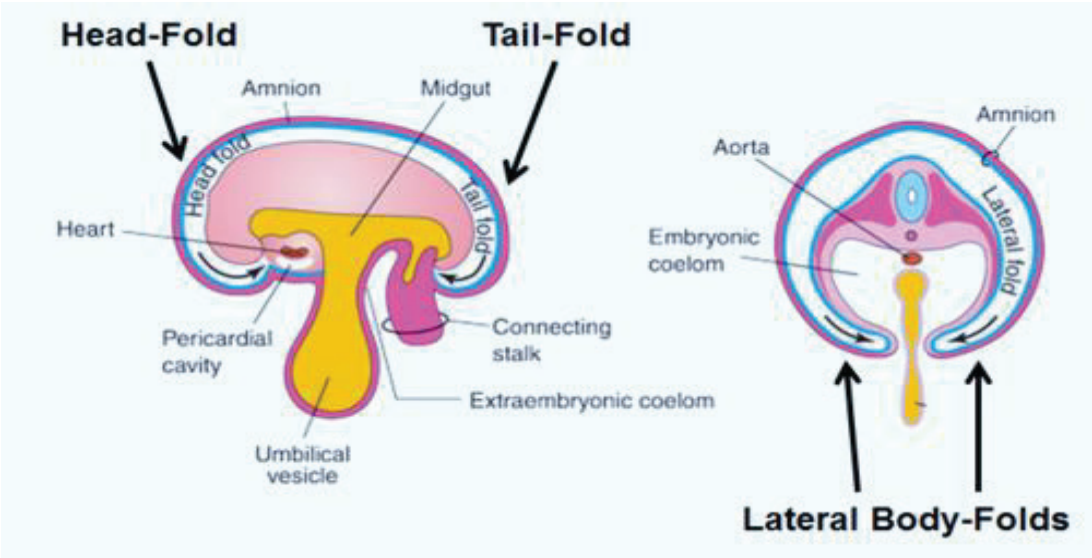
- Epithelial lining of the gastrointestinal tract, respiratory tract, the urinary bladder and most of the urethra.
- Epithelial lining of the tympanic cavity and auditory tube.
- The parenchyma of the tonsil, thyroid and parathyroid glands, thymus, liver and pancreas.

A. Epithelial Lining	B. Parenchyma
1. Gastrointestinal tract 2. Respiratory tract 3. Urinary gland 4. Most of urethra 5. Tympanic cavity and auditory tube	1. Tonsil 2. Thyroid 3. Parathyroid gland 4. Thymys 5. Liver and Pancreas

Folding of the Embryo

- **Definition:**
  - Folding means conversion of the flat trilaminar embryonic disc into a cylindrical embryo.
- **Time:**
  - Begins by the end of the 3rd week, and completed by the 4th week.
- **Types:**





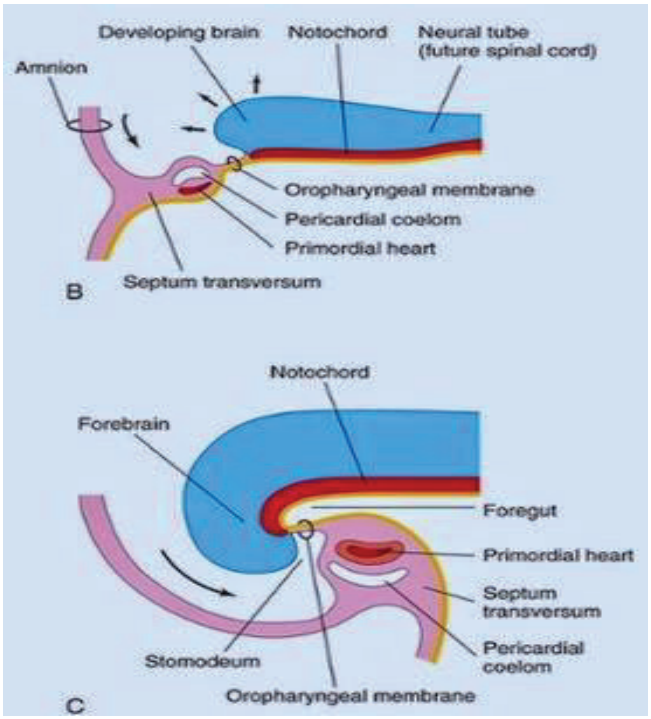
1. Cephalocaudal folding (head fold & tail fold):

- It is caused by the rapid longitudinal growth of the central nervous system.

A. The head fold:

Before folding:

- **The following structures are present in the midline of the embryo arranged in a craniocaudal direction:**
  a. Septum transversum (future central tendon of diaphragm)
  b. cardiogenic plate (future heart) and the pericardial cavity lies dorsal to the cardiogenic plate.
  c. Oral membrane (future mouth opening).
  - Early in folding at the beginning of the 4th week: the oral membrane shifted ventrally, and the cardiogenic plate shifted ventral to the oral membrane and the septum transversum lies ventral to cardiogenic plate.
  - **Late in folding The following structures lies ventral to the embryo and arranged in a craniocaudal order:**
    a. Oral membrane
    b. Cardiogenic plate
    c. Septum transversum
  - Part of the endodermal yolk sac is enclosed in the cranial part of the embryo it is called foregut.



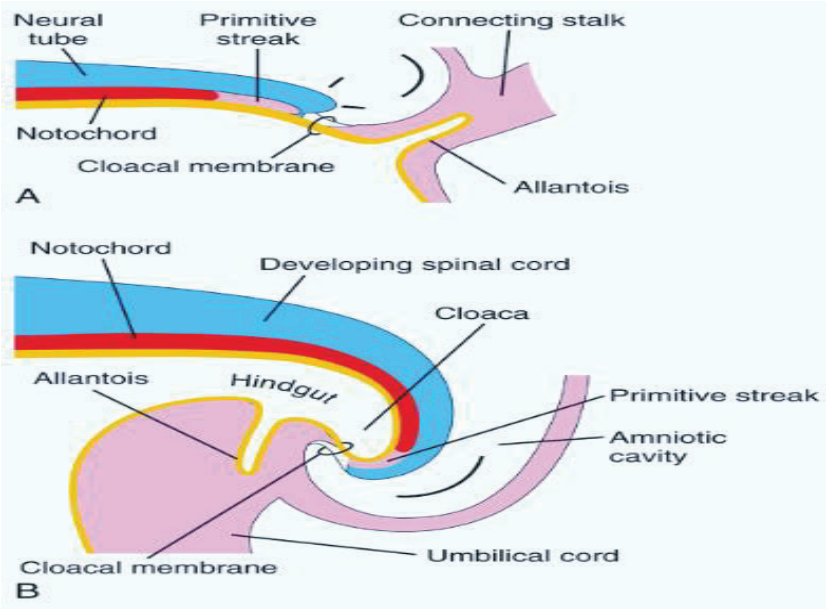
B. Tail fold:

Before folding

- The allantois is a pouch from the caudal part of the yolk sac.
- The yolk sac lies ventral to the endodermal layer of embryonic disc.
- The cloacal membrane lies in the caudal part of the embryo

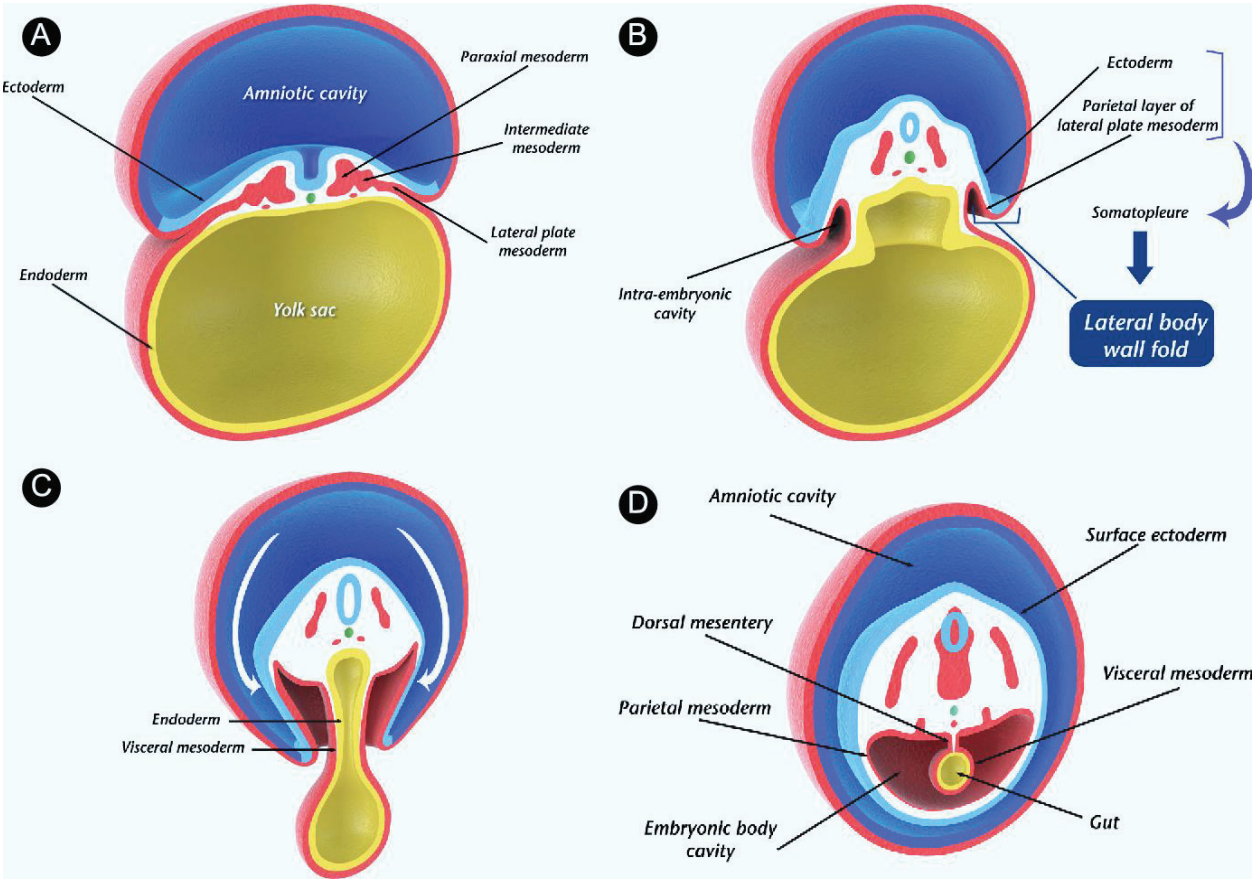
After folding:

- The allantois and the cloacal membrane shifted ventrally to the embryo
- Part of the yolk sac is incorporated in the caudal part of the embryo forming the hind gut.
- The terminal part of hind gut dilates to form the cloaca (future urinary bladder and rectum)



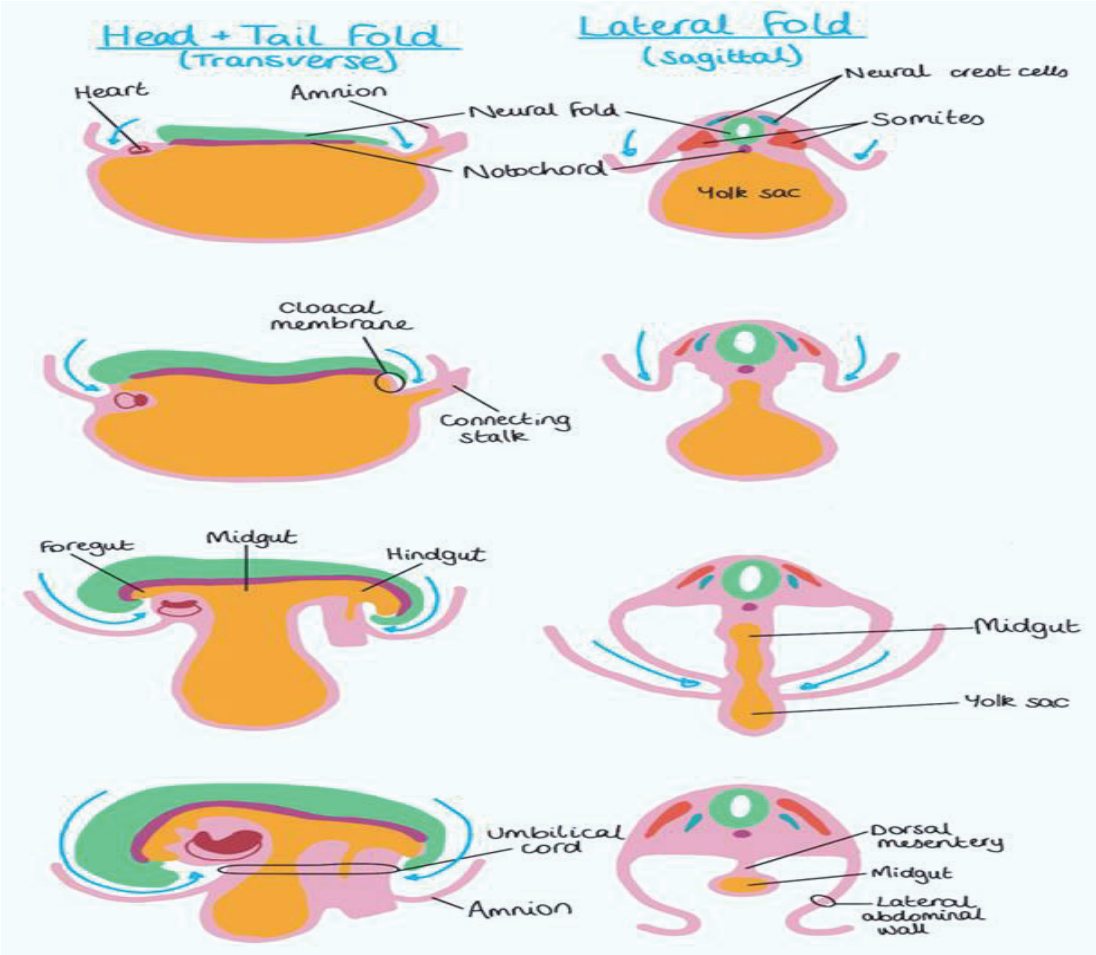
2. Lateral folding (right and left folds)

- It is due to the rapid growth of the somite (paraxial intraembryonic mesoderm).
- Lateral folding lead to formation of midgut connected to the extraembryonic yalk sac by the vitellointestinal duct or yolk stalk.
- The amniotic cavity increases in size on expense of the extraembryonic coelom.
- The amniotic cavity lies dorsal to the embryo before folding. After folding it lies cranial, dorsal, caudal and ventral to the embryo. at late stage of folding the amniotic membrane covers the umbilical cord.
- The extraembryonic coelom is obliterated by the increasing amniotic cavity, so the somatopleuric primary mesoderm lines the amniotic sac fuses with that lines the interior of the chorion.



- **Results of folding:**

1. It gives the embryo its cylindrical form.
2. Incorporation of part of yolk sac into the embryo to form the gut which is connected to the extraembryonic yolk sac by the vitellointestinal duct (yalk stalk).
3. As a result of formation of the head fold: The buccopharyngeal membrane, heart & septum transversum become ventral in position and arranged in a craniocaudal order.
4. As a result of formation of the tail fold: The cloacal membrane and allantois become ventral in position.
5. The umbilical cord is formed
6. The connecting stalk is shifted ventrally. The connecting stalk is a mass of somatopleuric primary mesoderm formed of reflection of somatopleuric primary mesoderm lines the amnion on those lines the chorion early it lies dorsal to the embryo then caudal, after folding it`s shifted ventral to the embryo.
7. The allantois (a diverticulum from the hindgut) becomes ventral instead of dorsal.

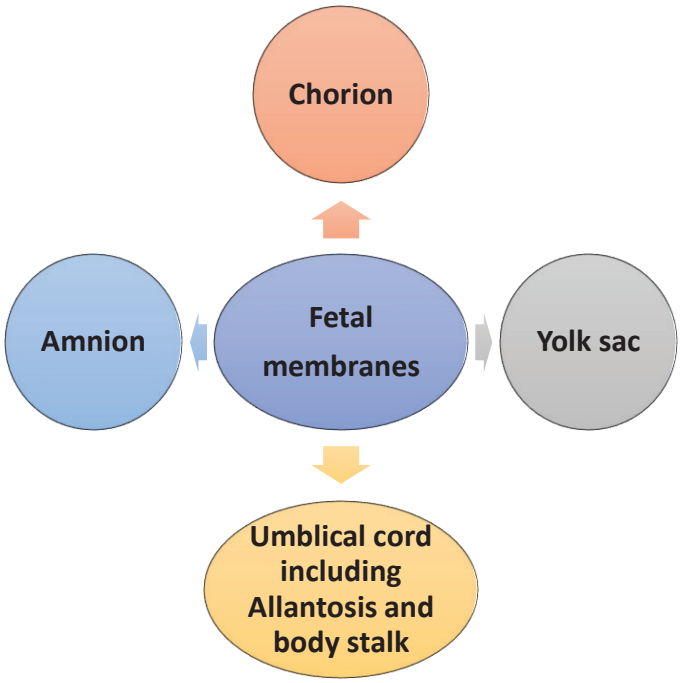


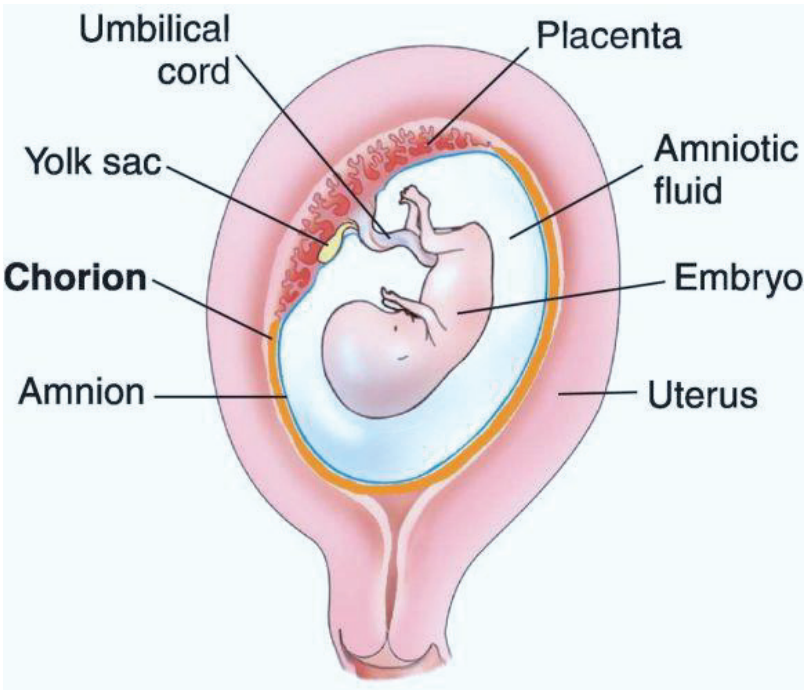
- **Changes during folding in relation to heart:**

	Before Folding	After folding
Septum-transversum	Cephalic	Caudal
Heart	Ventral (to pericardium)	Dorsal (to pericardium)
Pericardium	Dorsal	Ventral
Oral membrane	Caudal	Cranial
Allantois	Caudal	Ventral
Body stalk	Caudal	Ventral

Fetal membranes

- **Definition:**
  - Fetal membranes are all the structures that develop from the zygote and do not share in the formation of the embryo (extraembryonic structures from the primitive blastomeres).



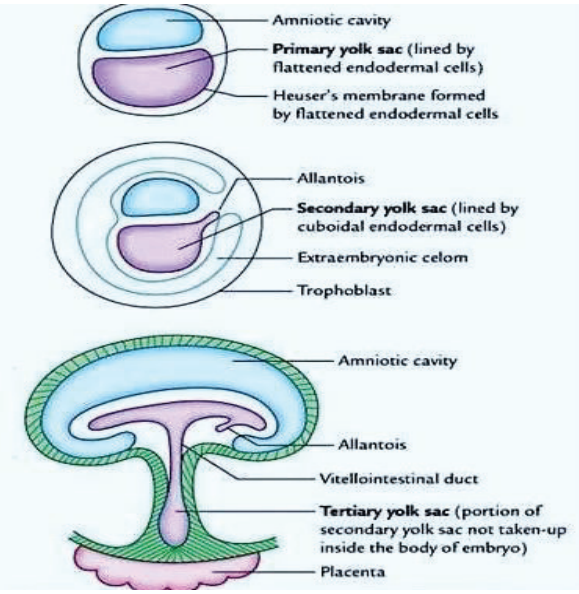


Yolk Sac

- **Development:**
  - **Primitive yolk sac** It`s formed in the ventral aspect of the embryonic disc (primitive yolk sac or exo-coelomic cavity).
  - Its roof is formed of the endodermal layer of the embryonic disc.
  - The remaining part of the is lined by flattened cells formed from the endodermal layer of the embryonic disc, covered by the extra-embryonic mesoderm.
  - Later on, due to growth of the embryo, the primitive yolk sac is reduced in size and transformed into **the secondary yolk sac** (formed of endoderm surrounded by a layer of splanchopleuric primary mesoderm).

Type of yolk sac	Formed of
Primitive yolk sac	▪ **Roof:** endodermal layer of the embryonic disc. ▪ **Remaining part:** lined by flattened cells formed from the endodermal layer of the embryonic disc.
Secondary yolk sac	▪ Endoderm surrounded by a layer of splanchopleuric primary mesoderm

- Blood vessels are formed in this mesoderm known as vitelline arteries and veins. After folding: The gut is formed as a result of folding of the embryo, thus part of the yolk Sac is taken inside of the embryo (the intra-embryonic portion of the yolk sac)
- This forms the foregut, midgut & hindgut. The midgut communicates with the extraembryonic part of the yolk sac by the yalk stalk.
- Growth of the embryo and the intestinal tract leads to the reduction in size of the yolk stalk (the vitellointestinal duct).
- This duct is lodged in the umbilical cord and later on it atrophies and disappeared completely



- **Fate of the yolk sac:**
  1. Formation of mucosal lining of Gastrointestinal tract
  2. The allantois develops from the dorsi-caudal part of the yolk sac After folding it is shifted ventrally and enclosed in the umbilical cord. Then obliterated forming the urachus, the urachus fibrosed to form the median umbilical ligament.
  3. The yolk stalk is formed as a constriction of the yolk sac, it connects the mid gut to the extraembryonic part of yalk sac. This stalk enclosed into the umbilical cord, later on it is obliterated and disappeared completely.

- **Functions of the yolk sac:**
  1. Formation of the mucosa of the alimentary canal and respiratory system
  2. Formation of the blood corpuscles.
  3. Vitelline vessels will give the superior mesenteric artery, portal and hepatic veins
  4. Some cells from the wall of the yolk sac (endoderm) migrate to the caudal end of the embryo. These cells are called the (primordial germ cells) which will form the gametes (sperms & ova).
  5. Formation of the major part of the urinary bladder and urethra.
  6. Formation of the umbilical blood vessels by the mesoderm surrounding the allantois.

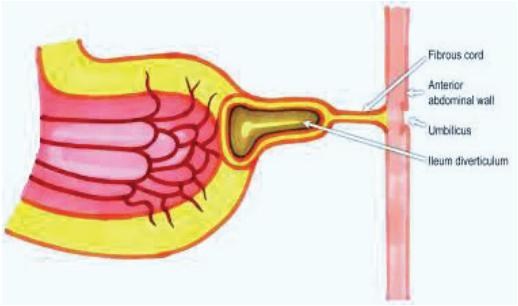
Abnormalities of the yolk sac (Abnormalities of vitelline duct)

1. Congenital umbilical fecal fistula:

- It is due to persistence of the vitello-intestinal duct
- Leading to an abnormal communication between the intestine (midgut) and the umbilicus
- It leads to discharge of feces from the umbilicus.

2. Meckel's diverticulum: (Role of 2)

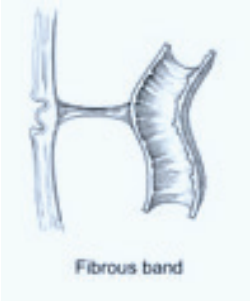
- It occurs due to patent intestinal end of the vitello-intestinal duct.
- The rest of the duct is degenerated or obliterated forming a fibrous band
- Meckel's diverticulum is a blind pouch about 3- 6 cm (2 inches) long that arises from the antimesentric border of the ileum, two feet from the iliocaecal junction.
- It occurs in 2- 4 % of people and is 3-5 times more prevalent in males than females.



- It might contain gastric mucosa which leads to its ulceration.
- Sometimes it becomes inflamed and causes symptoms like that caused by appendicitis.

3. Congenital umbilical sinus:

- It occurs due to patent umbilical end of the vitello-intestinal duct.

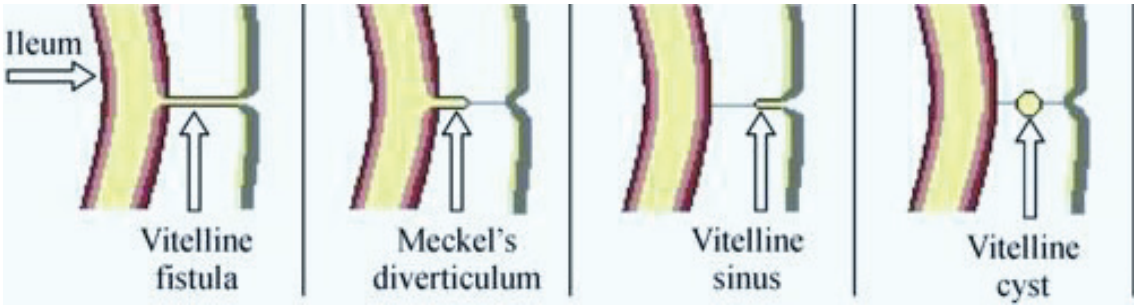


4. Fibrous band:

- Obliteration of the yolk stalk occurs but it remains as a Fibrous band.
- Intestinal obstruction may occur as a complication.

5. Vitelline cyst:

- Both ends of the vitello-intestinal duct close leaving an intermediate portion patent forming a cyst.



Allantois

- It's as a diverticulum from the caudal end of the yolk sac (cloaca after folding)
- It`s endoderm in origin, and embedded into mesodermal body stalk.
- The primary mesoderm covers it forms the umbilical blood vessels.
- Later, it degenerates leaving a remnant called the urachus that extends from the apex of the urinary bladder to the umbilicus.
- After birth it is fibrosed to form the median umbilical ligament.

- **Congenital anomalies of the allantois**

1. Urachal fistula:

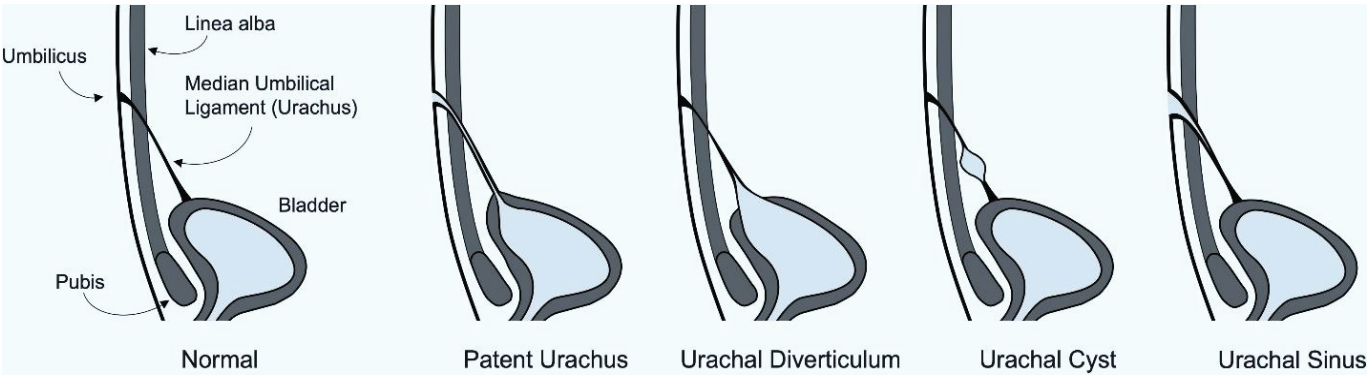
- The urachus fails to obliterate, It leads to urine discharge from the umbilicus due to its connection to the urinary bladder.

2. Urachal sinus:

- The proximal part of the urachus (part near the umbilicus) remains patent, while the rest of urachus is obliterated.

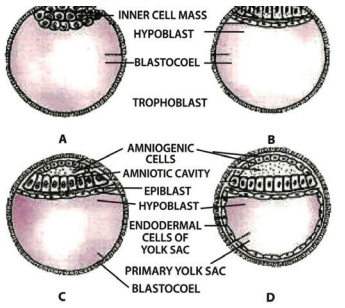
3. Urachal cyst:

- The middle portion of the urachus remains patent, the rest s obliterated.
- This leads to fusion between the somatopleuric primary mesoderm lines the amnion with that lines the inner aspect of trophoblast.

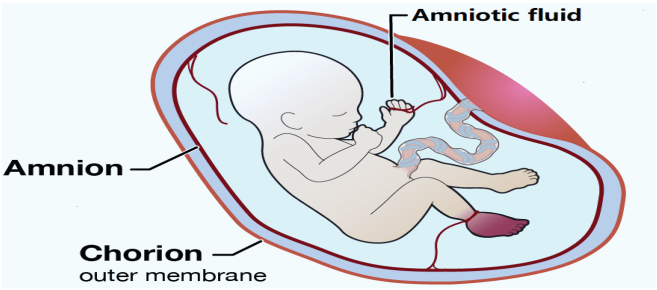


Amnion and Amniotic fluid

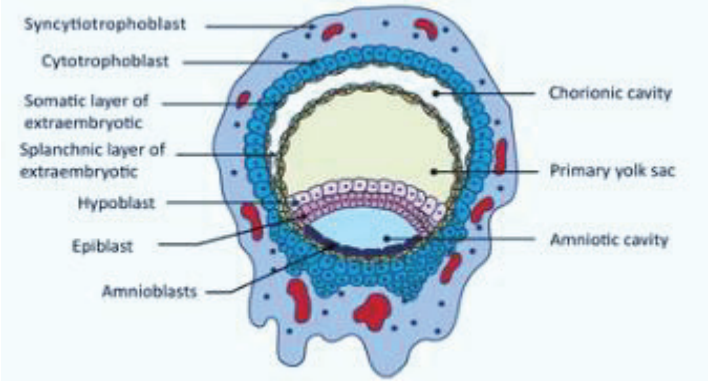
- **Definition:**
  - Amnion is a membrane which bounds the amniotic cavity.
  - It`s continuous with the ectoderm of the embryo.
  - The amniotic cavity contains about 800-1000 ml of watery and clear fluid at full term fetus.



A diagram showing the development of amnion and yolk sac

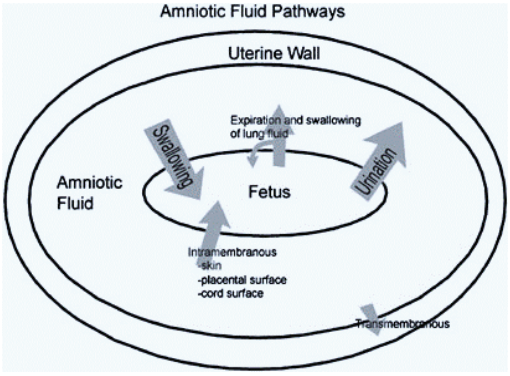


- **Development of the amnion:**
  - A small cavity appears within the epiblast layer of the inner cell mass (ectodermal layer called the amniotic cavity.
  - The cells of the epiblast (ectoderm) adjacent to the cytotrophoblast are called amnioblasts.
  - The amnioblasts (amniotic membrane) form the roof of the amniotic cavity.
  - The ectodermal layer of embryonic disc forms the floor of the cavity.
  - The amniotic cavity filled with amniotic fluid, it increases in size, the layer of the amnioblasts loses its contact with the inner surface of trophoblast and become known as the amnion.
  - After folding the amnion surrounds the embryo from all directions. It increases in size on expense of extraembryonic coelom until the coelom is obliterated, this leads to fusion between the somatopleuric primary mesoderm lines the amnion with those lines the inner aspect of trophoblast.



- **Sources of amniotic fluid:**
  - It`s formed mainly of water and comes from two sources:
    1. Maternal source, from diffusion of fluid from the uterine endometrium.
    2. Fetal source, from urine, feces (meconium) and respiratory secretion of the embryo.

- **Amniotic fluid Circulation:**
  - The amniotic fluid is not static but it`s changed every 3 hours (from the 5th month).
  - The fetus swallows the amniotic fluid which is absorbed through its gut into its blood stream.
  - Then, the amniotic fluid reaches the mother by passing through the placenta (placental barrier) or excreted as fetal urine



- **Fate of the amniotic fluid, amniotic membrane:**
  - **The amniotic membrane:**
    1. It surrounds the embryo (embryonic ectoderm).
    2. Gives a cover to the placenta, umbilical cord and chorion.
  - **The amniotic fluid:**

    During labor is subdivided into:

    a. Forewater
    - The part of the amniotic fluid that escapes "before" labor.

    b. Hindwater
    - The part of the amniotic fluid that escapes "after" labor

- **Clinical uses of the amniotic fluid:**

  The cells, DNA, enzymes, and protein in the amniotic fluid can be used to diagnose chromosomal anomalies of the embryo e.g., Down syndrome.

- **Functions of the amniotic fluid:**

I. During pregnancy:

1. The fluid allows free growth and movements of the fetus, absorb external trauma and prevents adhesions between the embryo and amnion.
2. Swallowing of the amniotic fluid stimulates the fetal suckling reflex.
3. It maintains a constant temperature around the fetus.
4. It permits normal development of the fetal lung.
5. It maintains normal balance between fetal fluid and electrolytes (fetal homeostasis).

II. During labor:

1. It forms the bags of forewater and hindwater the bag of forewater allows regular dilatation of the cervix, and cleans the female passages before labor.
2. After rupture of the membrane, the amniotic fluid serves as a lubricant to facilitate the descent of the fetus.
3. The amniotic fluid is bacteriostatic to the female genital system.

- **Abnormalities of the amniotic fluid:**

1. Oligohydramnios:

- The amniotic fluid is less than 400 ml.
- It may lead to adhesions between the fetus and its amnion.
- It leads to club foot and lung hypoplasia.
- It is associated with renal agenesis of the fetus.

2. Polyhydramnios:

- The amniotic fluid is 1500-2000 ml at birth.
- It is associated with esophageal atresia of the fetus or diabetes mellitus of the Mother
- Polyhydramnios may cause premature labor

3. Caul de sac:

- The embryo may be delivered without rupture of the amniotic sac.

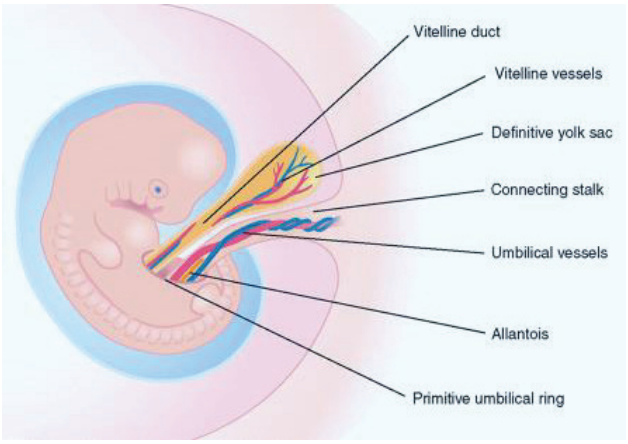
Umbilical cord

- **Definition:**

  It`s the area of communication between the fetal surface of placenta and embryo after folding.

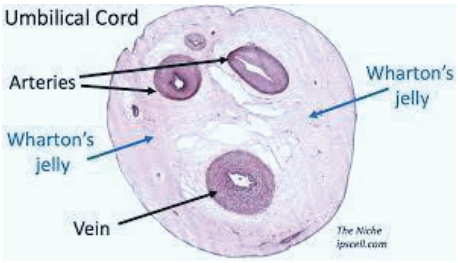
- **The structures forming the primitive umbilical cord: (Before birth)**

  1. Yolk stalk and the vitelline blood vessels.
  2. Ectoderm of the amnion.
  3. Body stalk (extraembryonic mesoderm).
  4. Allantois (endoderm).
  5. Part of extraembryonic coelom:
     - The small intestine (midgut loop) normally herniates in this extraembryonic coelom.
     - At the 10th week the intestine is reduced back into the abdominal cavity and the extraembryonic coelom is obliterated to prevent re-herniation of the intestine.
  6. Umbilical blood vessels.



- **Fate of body stalk:**

  It forms the jelly of Wharton of the definitive umbilical cord



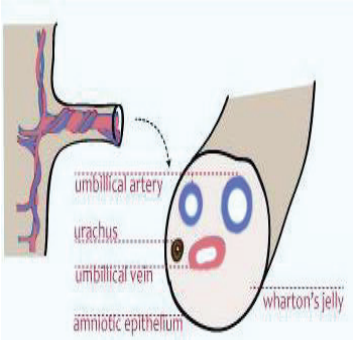
- **Fate of yolk sac stalk**
  - It`s a narrow space connecting the midgut with the extraembryonic yolk sac and contains the vitelline vessels.
  - Later on, it is obliterated and disappeared; the vitelline arteries will form the artery of midgut (superior mesenteric artery).

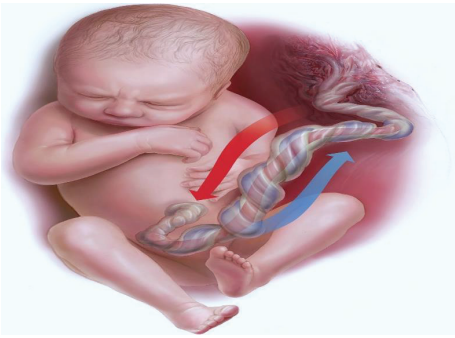
- **Fate of allantois:**
  - It`s a small blind ended pouch arising from the hind gut and invades the body stalk
  - The primary mesoderm around it forms the umbilical blood vessels.
  - The allantois obliterated forming the urachus, after that it transformed into median umbilical ligament

- **Structures of the definitive umbilical cord at birth:**

1. It`s 30-90 cm long (average is 55 cm) and 2 cm in diameter.
2. It is spirally twisted due to the long 2 umbilical arteries compared to relatively short umbilical vein; this leads to appearance of false knots.
3. It`s shiny because it is covered by the amnion.
4. It`s attached to the center of the placenta.
5. **Contents:**

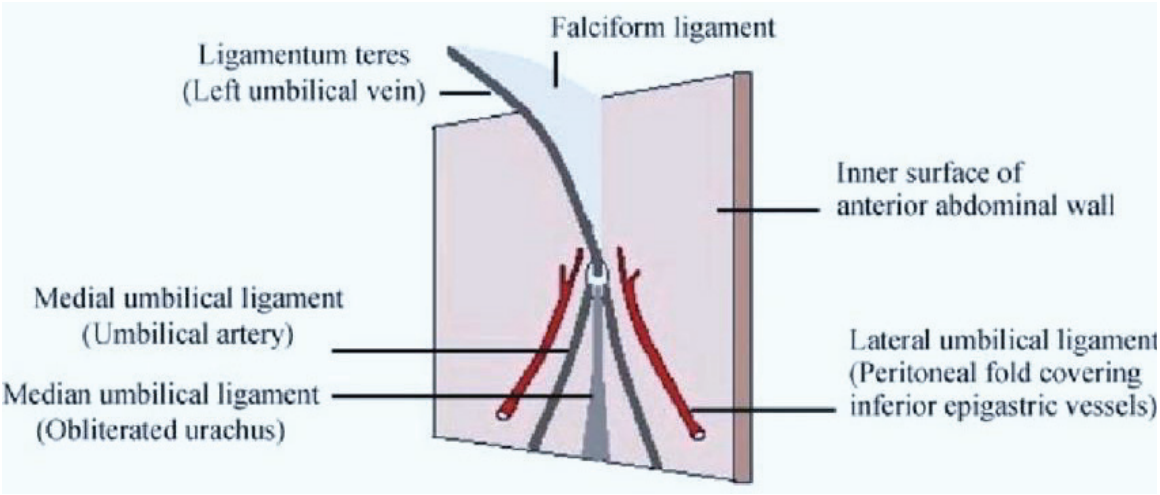
i. Wharton's jelly
ii. Two umbilical arteries
iii. Single left umbilical vein
iv. Allantois (urachus)
v. Remnant of the vitello-intestinal duct and remnant of the extraembryonic coelom.





- **Postnatal changes in the umbilical cord:**

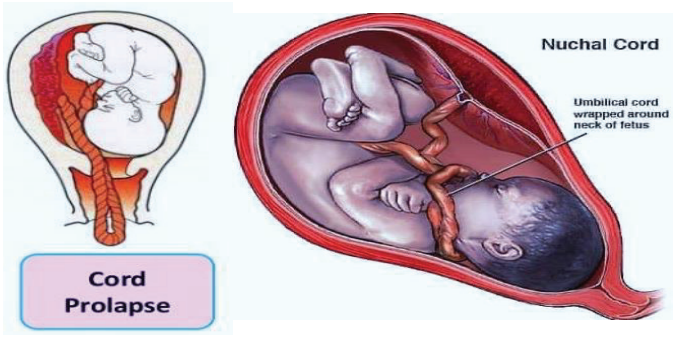
Two umbilical arteries	Two medial umbilical ligaments
Left umbilical vein	Ligamentous teres of liver
Allantois (Urachus)	Median umbilical ligament



- **Abnormalities of the umbilical cord:**

1. Long umbilical cord:

This may lead to cord prolapse or the cord may encircle the neck of the fetus causing fetal strangulation.

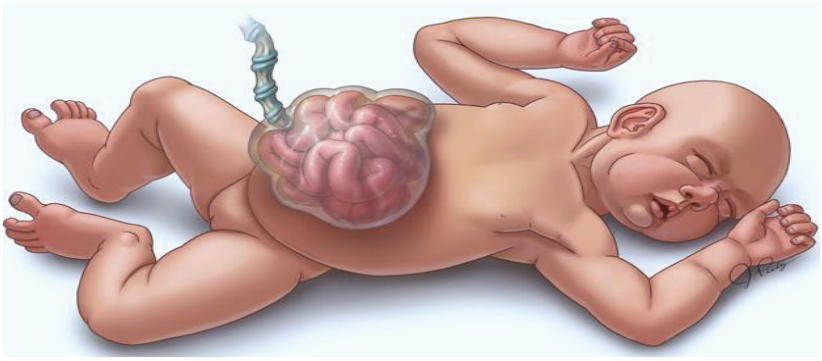


2. Short umbilical cord:

This might cause premature separation of the placenta or rupture of the cord during delivery or may cause inversion of the uterus of the mother.

3. Omphalocele (exomphalos):

Large part of small intestine covered with membrane may remain herniated in the cord (fails to return to the fetal abdominal cavity) Therefore, the cord should be ligated away from the umbilicus to avoid ligation of the intestine in the ligature.



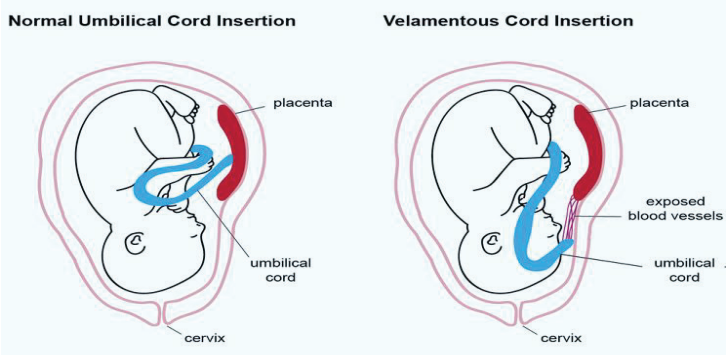
4. Double or triple cord.

5. Cord with true knots

(occurs in about 1% of pregnancies) This leads to obliteration of umbilical blood vessels.

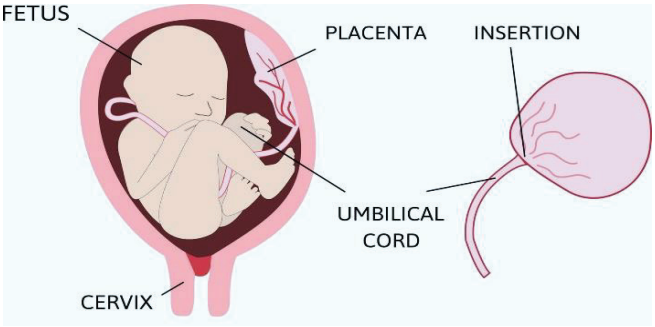
6. Velamentous attachment to the placenta

The umbilical cord does not reach the placenta and the umbilical blood vessels run along the amnion to the placenta.



7. Marginal attachment of the cord to the placenta

This is called battle-dore placenta.

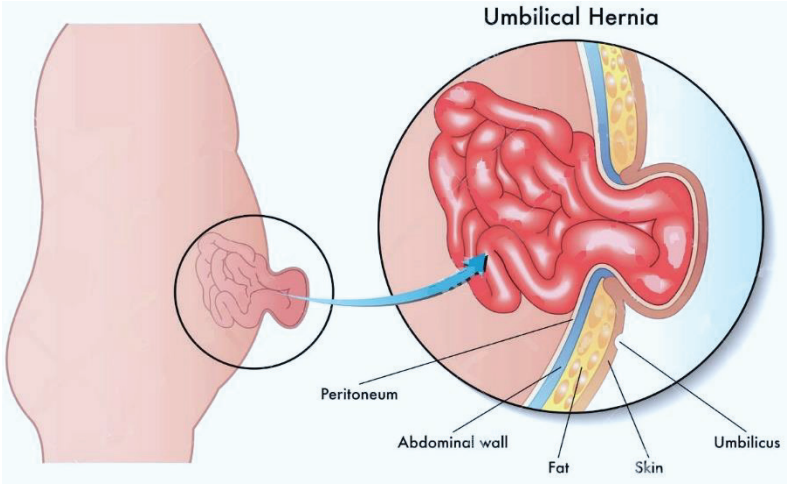


8. Single umbilical artery:

It occurs due to genetic causes; its incidence is about one in 200 newborns.

9. Congenital umbilical hernia:

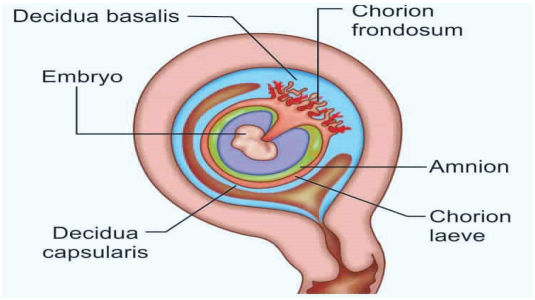
Small part of intestine herniates through the umbilicus of the new born this structure covered with skin It is due to weakness of the anterior abdominal wall.



Placenta المشيمه

The placenta is the site of nutrient, gas exchange and excretion between the fetus and mother.

- **Development of the placenta:**
  - At first, the chorionic villi cover the entire surface of the chorion.
  - Later on, the villi opposite the decidua basalis continue to grow and expand to form chorion frondosum.
  - While the villi related to the decidua capsularis degenerate and this part of chorion called chorion leave.

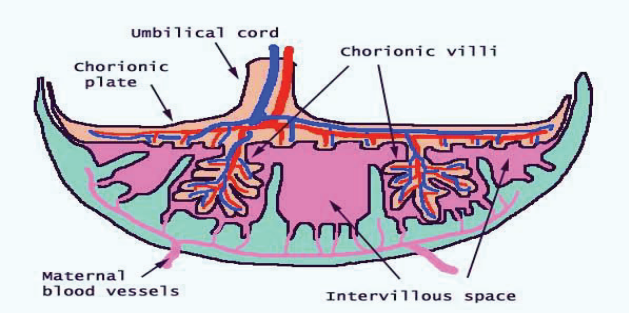


- **The placenta is formed by:**

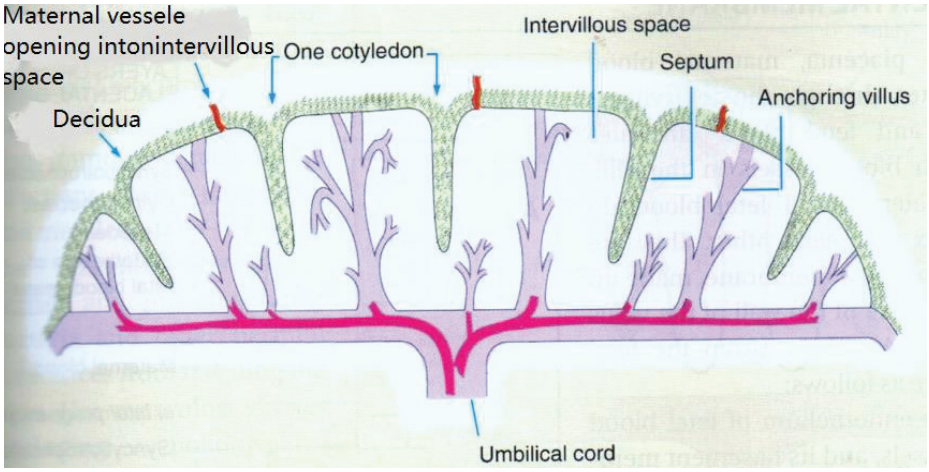
  A. Mainly by the chorion frondosum (the fetal part, chorionic plate).

  B. A small extent by the decidua basalis (the maternal part, decidual plate).

- **Structure of the placenta:**
  - Formation of the placenta started at the 4th month
  - Spaces between the villi appears and fuse together forming the intervillous spaces.
  - They are filled with maternal blood.
  - This blood leaked from the spiral arteries eroded by fetal chorionic villi.
  - Later on, a number of decidual septae attached to decidual plate are formed.
  - These septa project into the intervillous spaces, but do not reach the chorionic plate, so it is incomplete septum.
  - As a result of these septa, the maternal surface of the placenta s divided into compartments; each one is called "cotyledon".



  - The intervillous spaces in all the cotyledons are communicating with each other.
  - As pregnancy advances, the placenta increases in size by formation of new villi, and in thickness due to the extensive arborization (branching) of the villi.



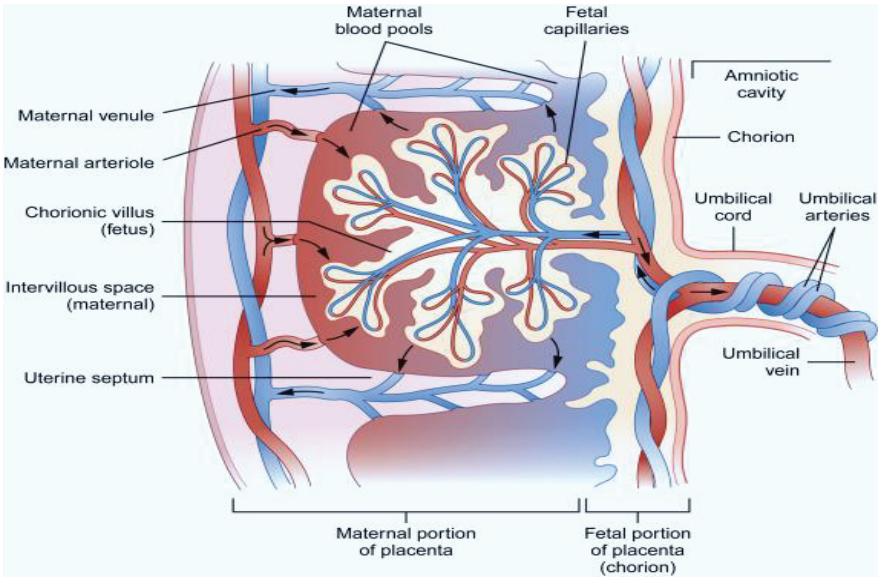
- **Placental circulation:**

1. Maternal placental circulation:

- **Arterial oxygenated blood:** reaches the intervillous spaces through spiral endometrial arterioles (higher pressure) that pierce the decidual plate and enter the intervillous spaces. This carries nutrients and antibodies into the intervillous spaces surrounding the villi.
- **Deoxygenated blood:** passes back towards the decidua to the maternal circulation through the endometrial venules (lower pressure) carrying the fetal carbon dioxide and waste products.

2. Fetal placental circulation:

- The umbilical vessels divide into many chorionic vessels in the chorionic villi.
- Exchange of gases and metabolites occurs through the wall of the villi (Placental barrier).
- Oxygen and nutrients pass through the "umbilical vein" to the fetus.
- Fetal CO_2 and waste products pass through the "umbilical arteries"



- **The placental membrane (placental barrier):**
  - It`s the structures that separate the maternal and fetal blood.
  - It`s not a true barrier because few substances are able to cross it.
  - Most drugs in the maternal blood can pass through it to the fetal circulation.
  - Some of which can harm the fetus and cause major congenital anomalies.

Early in pregnancy (till about 20-week gestation):

- **Placental barrier is formed of four layers:**

a. The endothelial lining the fetal vessels.
b. The connective tissue (primary mesoderm) of the villus.
c. The cytotrophoblast layer.
d. The syncytiotrophoblast.

Trophoblast

After 20 weeks:

The cytotrophoblast degenerate so increases the permeability of the placenta.

- **Placental barrier is formed of:**

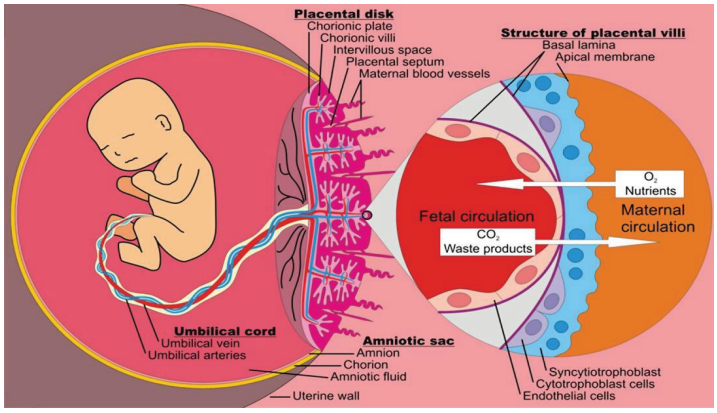
a. The endothelial lining the fetal vessels.
b. The connective tissue (primary mesoderm) of the villus.
c. The syncytiotrophoblast.

Towards the end of pregnancy:

A fibrinoid material made of fibrin is formed on the surface of the villi to decrease the permeability

- **Placental barrier is formed of:**

a. The endothelial lining the fetal vessels.
b. The connective tissue (primary mesoderm) of the villus.
c. The syncytiotrophoblast.
d. The fibrinoid material



The fetal circulation and maternal circulation are closed circulations, meaning that maternal blood and fetal blood does not mix.

- **Function of the placenta:**

1. **Exchange of gases (respiration):** Oxygen, carbon dioxide is transported by simple diffusion.
2. **Exchange of nutrients, water, and electrolytes (nutrition):** as amino acids, fatty acids, carbohydrates and vitamins.
3. **Transmission of maternal antibodies to** the fetus resulting in passive immunity.
4. **Excretion as fetal waste products** e.g., urea and uric acid pass through it from fetal to maternal blood.
5. **Selective barrier (protection)**

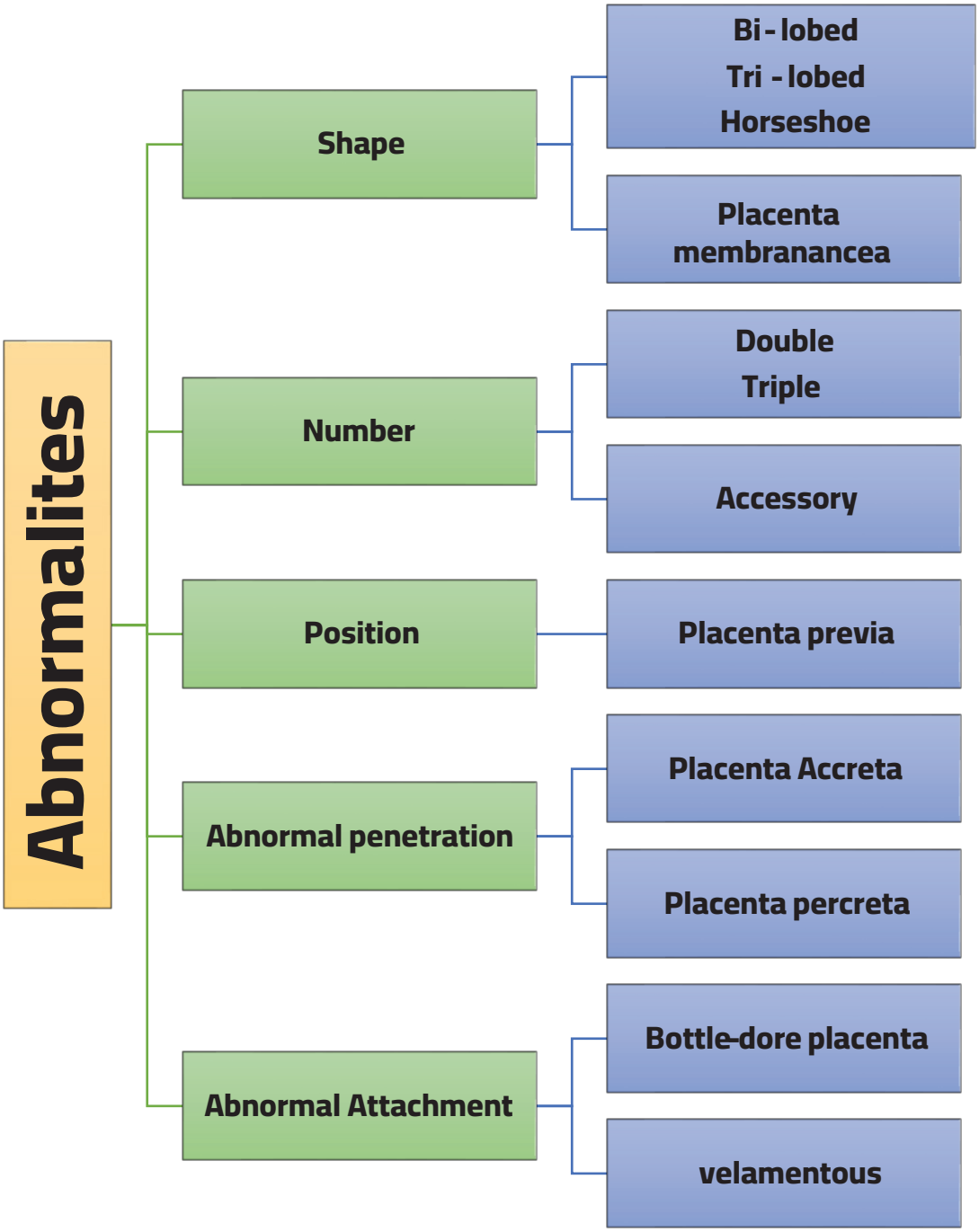
- Against the transmission of diseases from the mother to the fetus.
- However, many maternal infectious agents as viruses of rubella, measles, cytomegalovirus, and toxoplasma can cross the placenta causing severe congenital malformations or fetal death

6. **Hormone production:**

- By the end of the 4th month, the placenta secretes the following hormones by the syncytiotrophoblast:

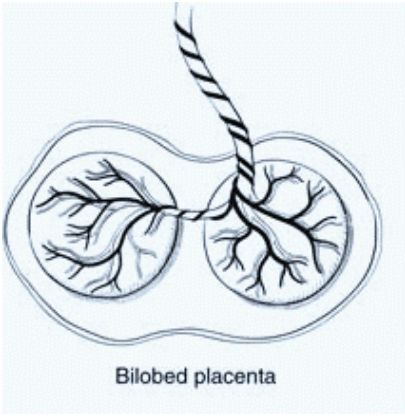
a. **Progesterone:** it replaces the corpus luteum and preventing menses during pregnancy
b. **Estrogenic (estriol)** hormones.
c. **Gonadotrophins:** as human chorionic gonadotrophins (HCG), somato-mammotropin, human chorionic thyrotropin, and human chorionic corticotropin.
d. **Relaxin hormone:** to soften the ligaments of the pelvis in preparation for birth of the fetus.

- **Abnormalities of the placenta**



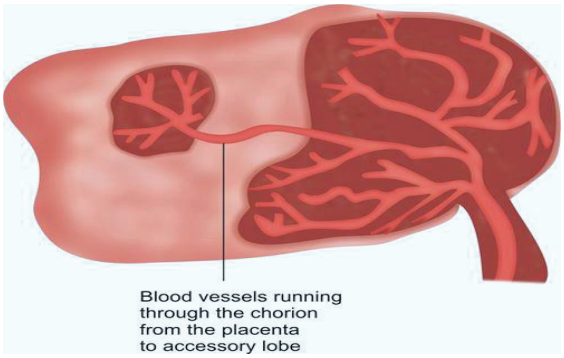
1. Shape abnormalities:

- Bilobed, trilobed or horseshoe
- Placenta membranacea (diffuse placenta) i.e., a thin layer of placenta attaches to a large area of the uterus.


Bilobed placenta

2. Number abnormalities:

- Double placentae.
- Triple placentae.
- Accessory placenta It may cause severe postpartum hemorrhage if it is retained in the uterus after labor.



3. Position abnormalities:

- **Placenta previa**

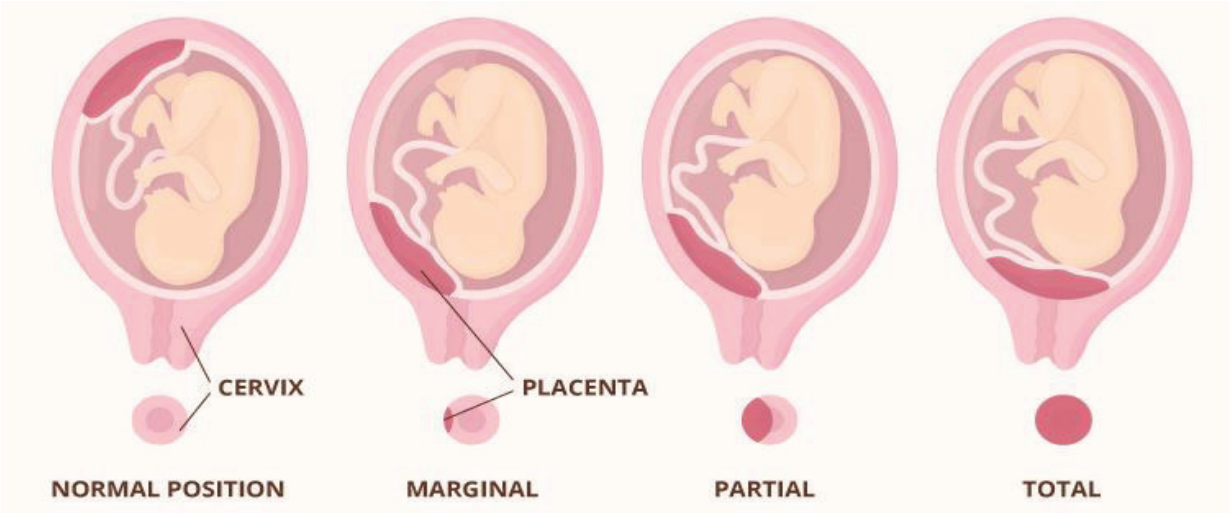
  where the placenta is attached to the lower uterine segment (due to low level of implantation of the blastocyst). It causes severe antepartum hemorrhage.

- **There are three types of placenta previa:**

  a. **Placenta previa centralis:** the center of the placenta covers the internal os of the cervix of the uterus.

  b. **Placenta previa marginalis:** It covers the internal os incompletely. During pregnancy, the placenta is shifted upwards away from the internal os and becomes as placenta previa lateralis (parietalis).

  c. **Placenta previa parietalis:** It`s attached to the lower segment away from the internal os.



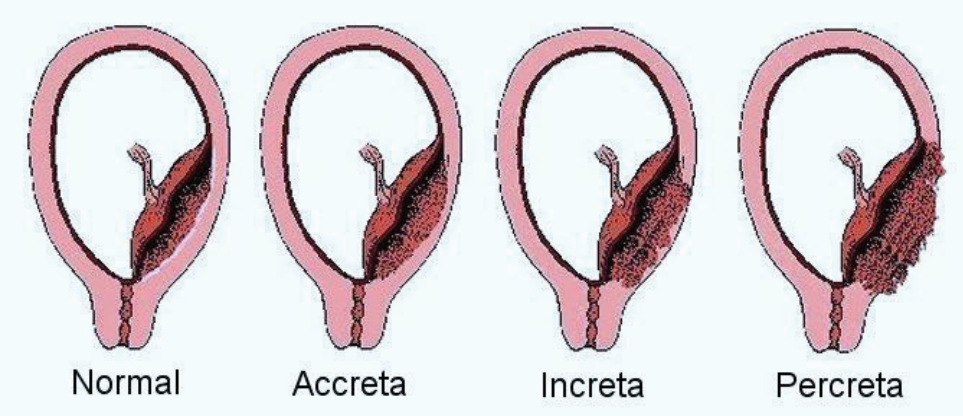
4. Abnormal penetration to the uterine wall

a. Placenta accreta:

- Due to abnormal adhesion between the chorionic villi and the uterine wall due to excessive penetration of the endometrium.

b. Placenta percreta:

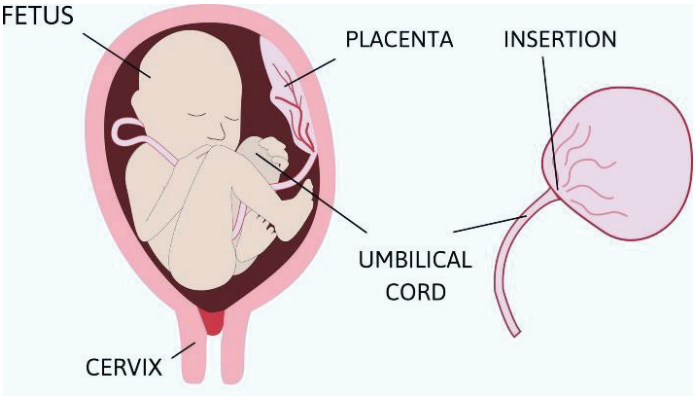
- The chorionic villi penetrate the myometrium all the way to the perimetrium (uterine peritoneal covering).
- In these two abnormalities the placenta fails to separate from the uterus after birth of the fetus and may cause severe postpartum hemorrhage.



5. Abnormalities due to attachment of the umbilical cord:

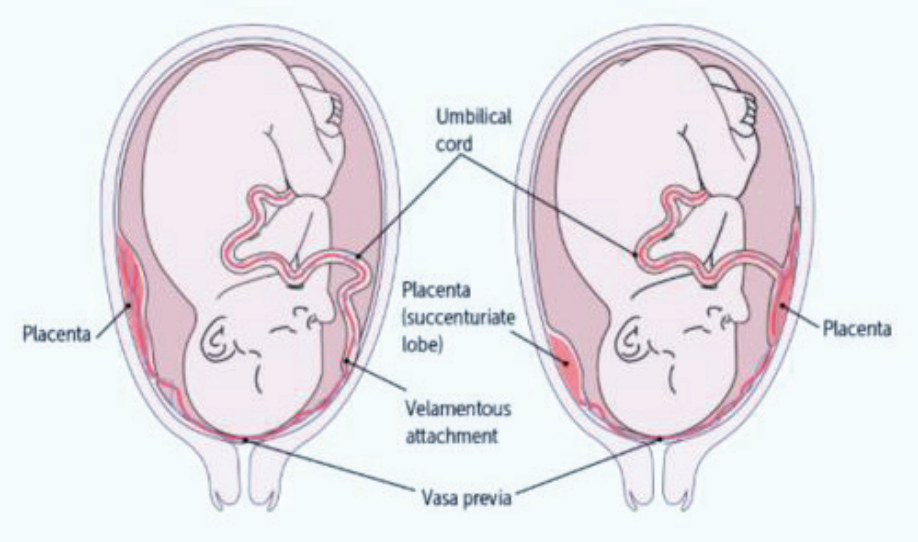
a. Battle-dore placenta:

- The cord is attached to the margin of placenta.
- It is named so because of its resemblance to the bat used in the medieval game of battledore and shuttlecock.



b. Velamentous placenta:

The cord is not attached to the placenta, and the umbilical blood vessels reach the placenta by passing in the amniotic membrane.



- The cord is attached to the membranes (amnion and chorion), not to the placenta.
- The umbilical vessels leave the cord and run between the amnion and chorion before spreading over the placenta.
- The vessels are easily torn in this location, especially when they cross over the inferior uterine segment; this condition is known as vasa previa.
- If the vessels rupture before birth, the fetus loses blood and could be near exsanguination when born.