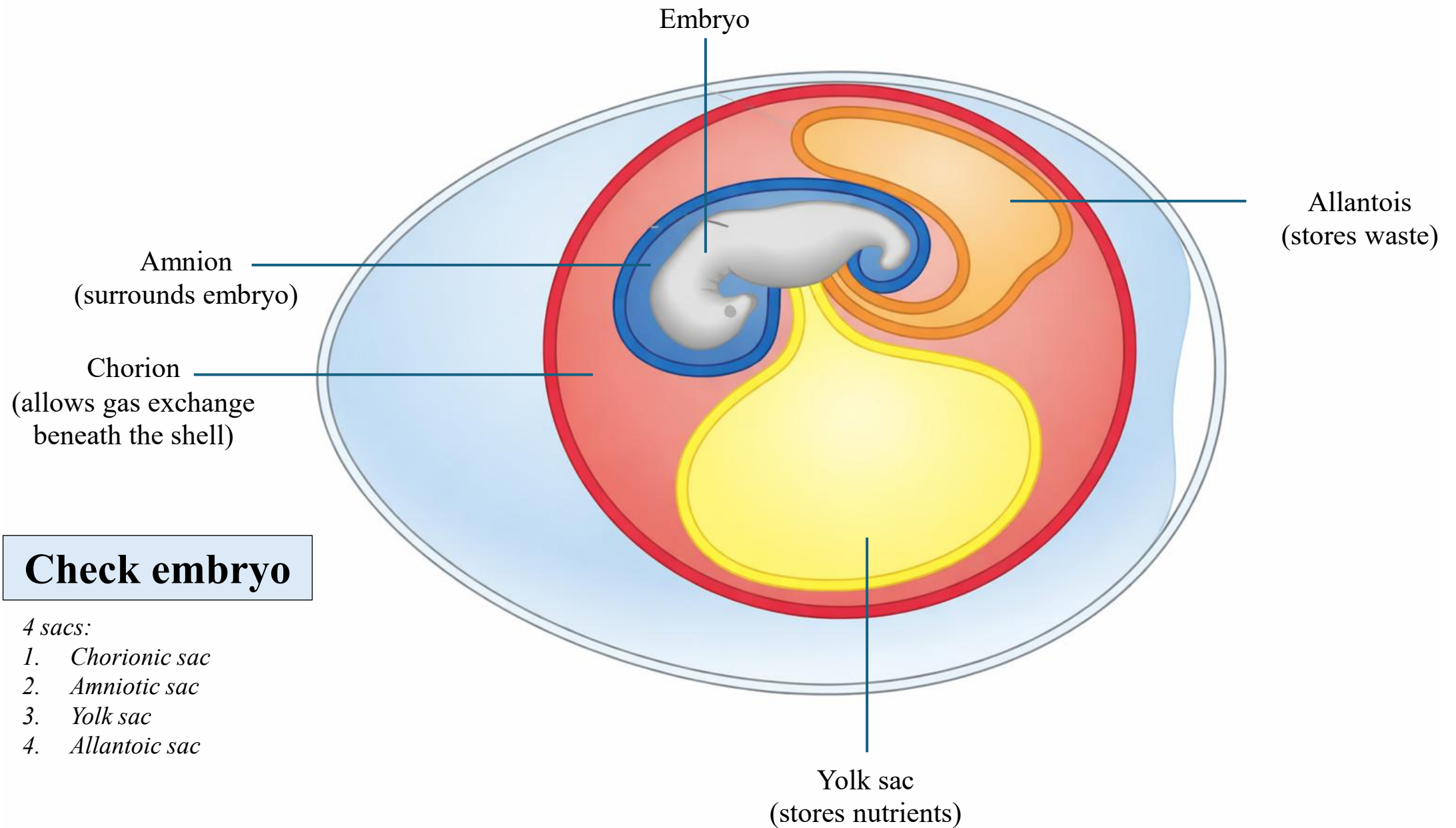




Fetal Membranes and Umbilical Cord

Dr. Heba Kalbouneh
DDS, MSc, DMD/PhD
Professor of Anatomy, Histology and Embryology

*Prepared and adapted for teaching by Prof. Dr. Heba Kalbouneh.
Illustrations adapted from multiple educational resources for educational purposes.
These slides are intended for students enrolled in this course and should not be
distributed without permission.*



Check embryo

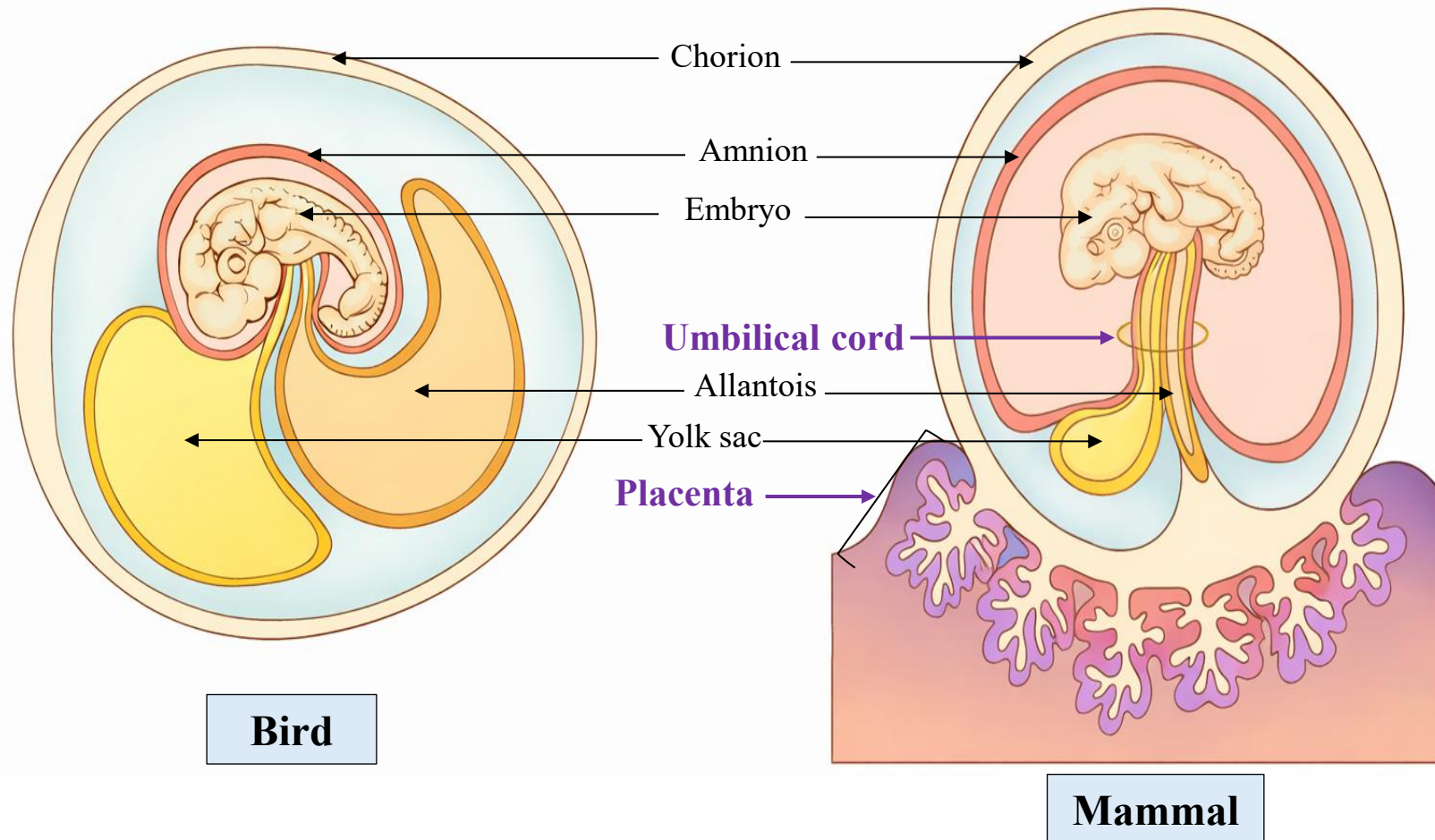
4 sacs:

1. Chorionic sac
2. Amniotic sac
3. Yolk sac
4. Allantoic sac

The fetal membranes are a group of structures which are **VERY ESSENTIAL** for the development of the fetus, but they don't enter in its structure (except for the intraembryonic portion of allantois and the intraembryonic part of yolk sac)



- Fetal membranes:**
- Amnion**
 - Chorion**
 - Yolk sac**
 - Allantois**
 - Placenta**

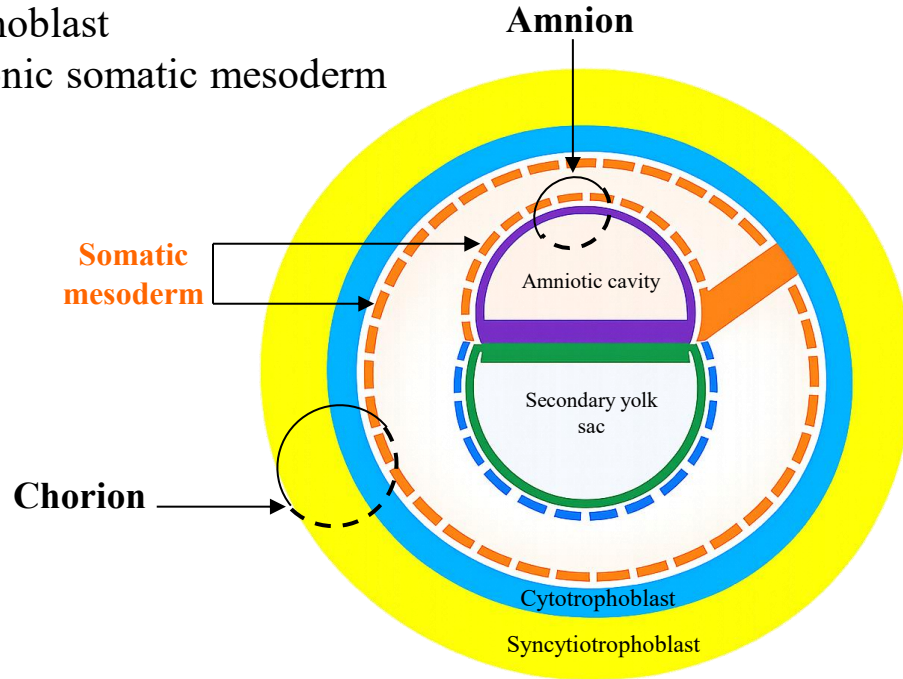


Note: In mammals (including humans), nutrient supply and waste removal occur via the placenta; therefore, the yolk sac and allantois do not function as primary organs of nutrition and excretion as they do in birds.

Chorion المشيماء is the outermost fetal membrane that surrounds the amnion and contributes to placenta formation.

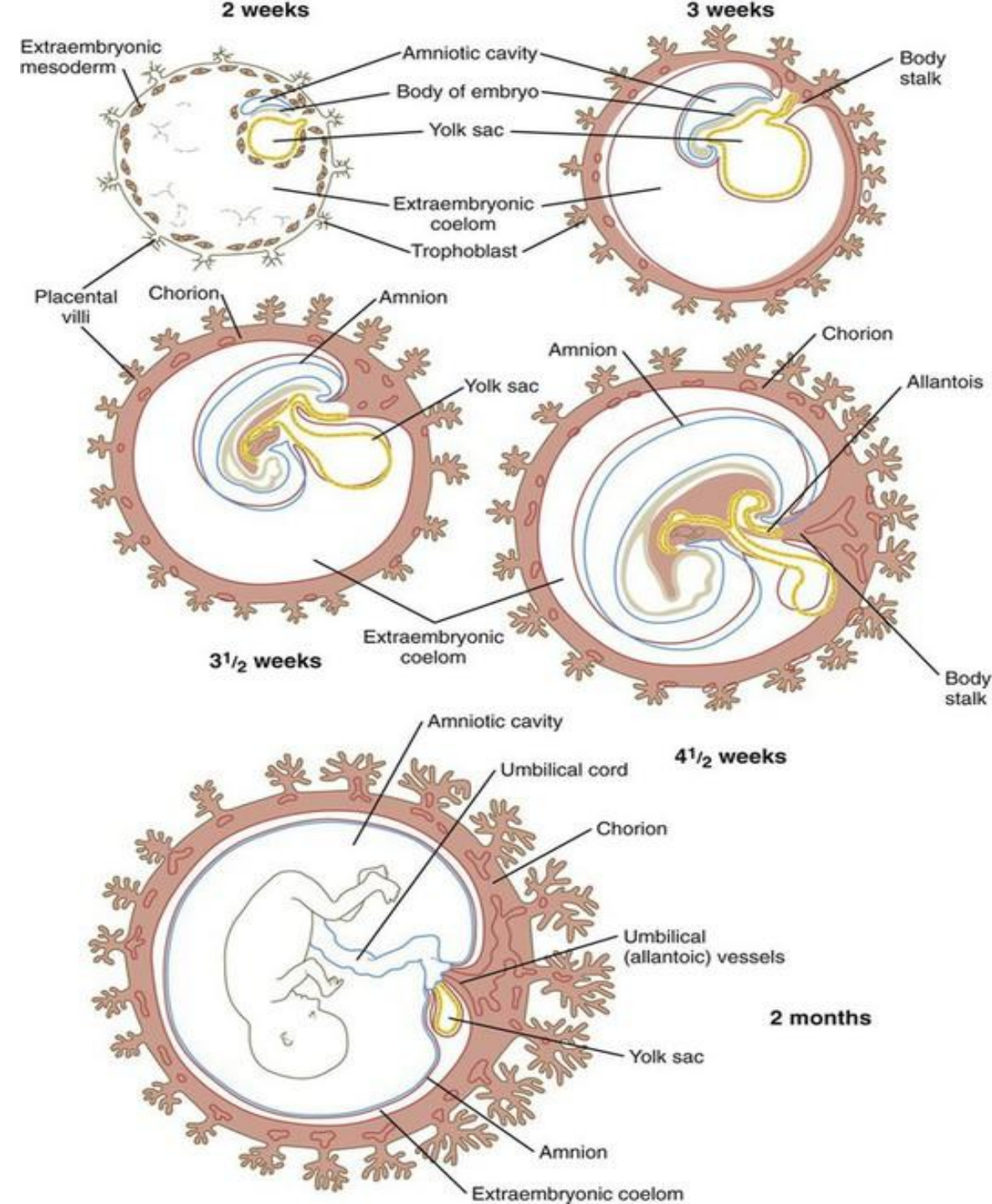
It is formed by:

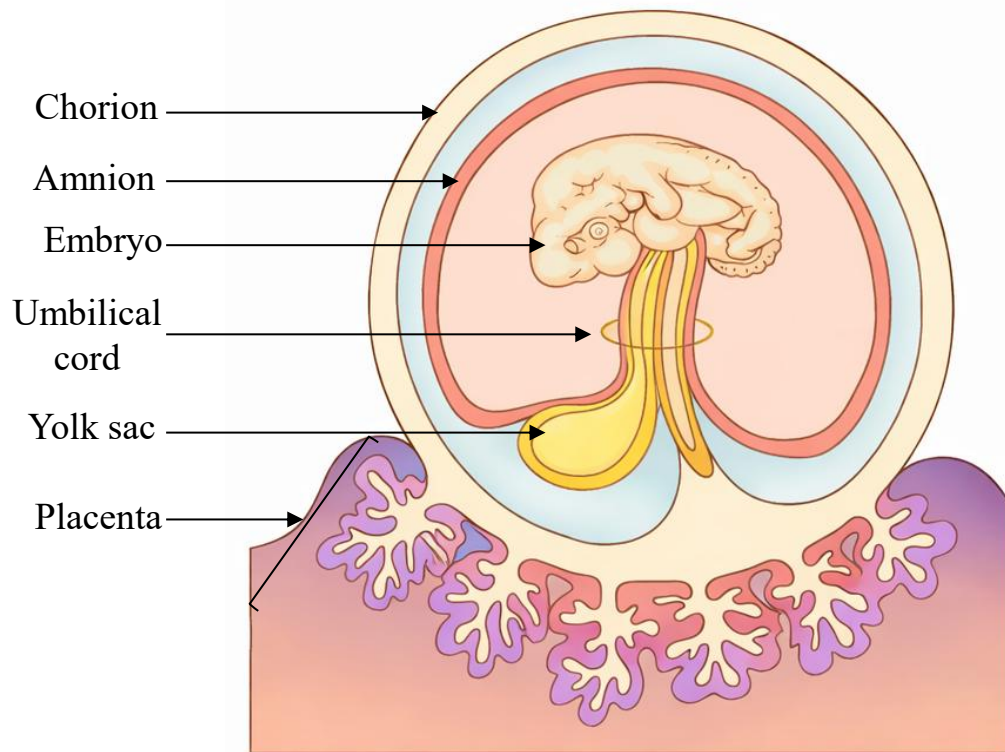
1. Cytotrophoblast
2. Syncytiotrophoblast
3. Extra-embryonic somatic mesoderm



Amnion الأمنيون is the innermost fetal membrane that surround the embryo. It forms the amniotic sac around the developing embryo. The amniotic cavity, filled with amniotic fluid, cushions and protects the embryo/fetus and allows normal growth and movement.

Amnion = Amnioblasts + somatic extraembryonic mesoderm





Amnion
 Meaning (Greek): “Lamb” or “membrane around a lamb fetus”

Chorion
 Meaning (Greek): “Skin” or “outer covering”

Will be covered with placenta

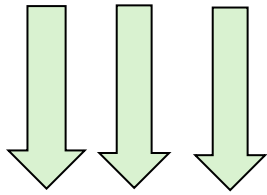
Feature	Amnion	Chorion
Definition	Inner fetal membrane that surrounds the embryo	Outer fetal membrane that surrounds the amnion
Position	Innermost fetal membrane	Outermost fetal membrane
Main content	Amniotic fluid	Chorionic cavity (early)
Function	Protection, cushioning, allows fetal movement	Involved in placenta formation
Contribution to placenta	✗ No	✓ Yes (forms chorion frondosum)
Embryological origin	Amnioblasts (from epiblast) + extraembryonic somatic mesoderm	Trophoblast + extraembryonic somatic mesoderm
Later in pregnancy	Remains as the amniotic sac	Fuses with amnion → amniochorionic membrane

Amnion

The amnion is a thin membrane that encloses the amniotic cavity.

Formation

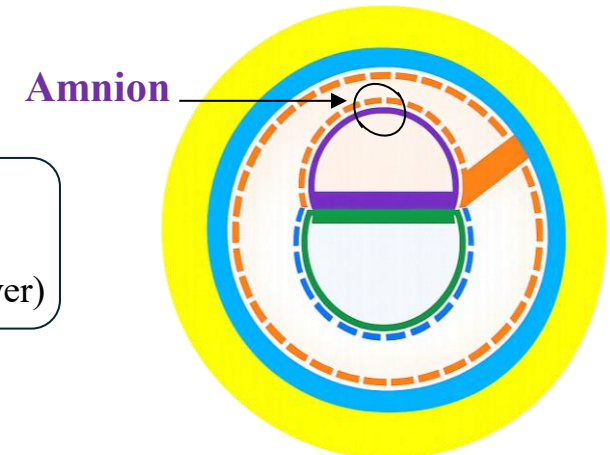
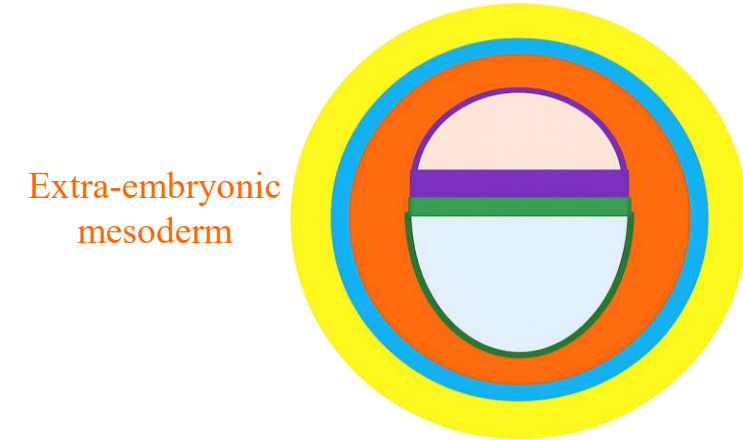
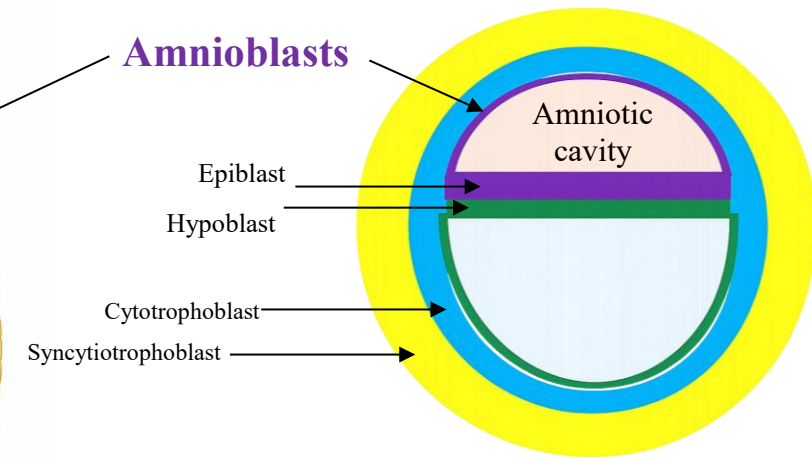
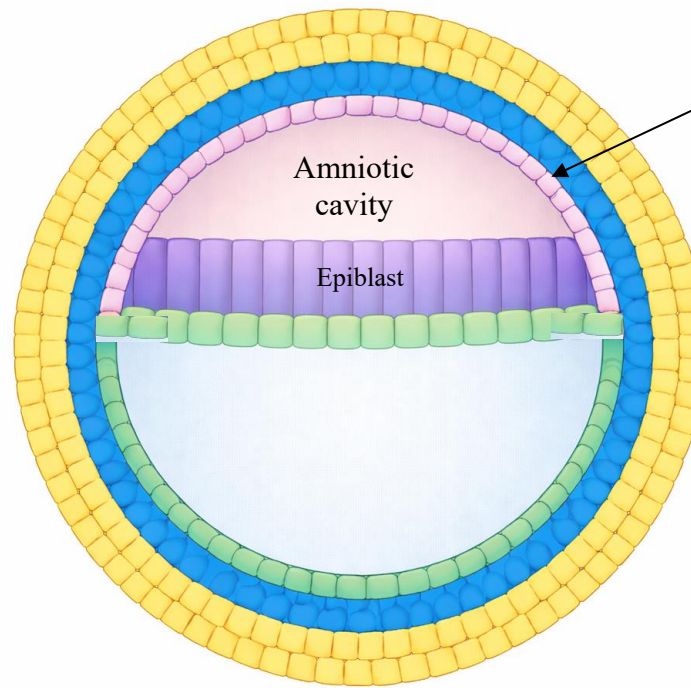
- ✓ On the 8th day, a small cavity appears within the epiblast.
- ✓ Epiblast cells differentiate into amnioblasts, which line the roof of the cavity.



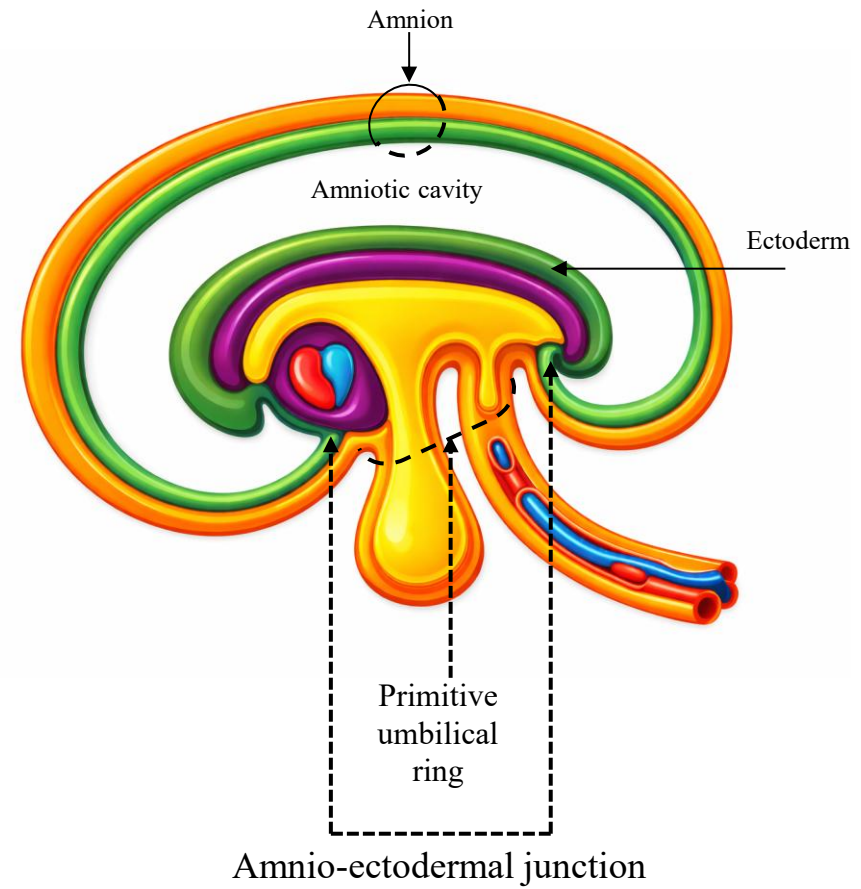
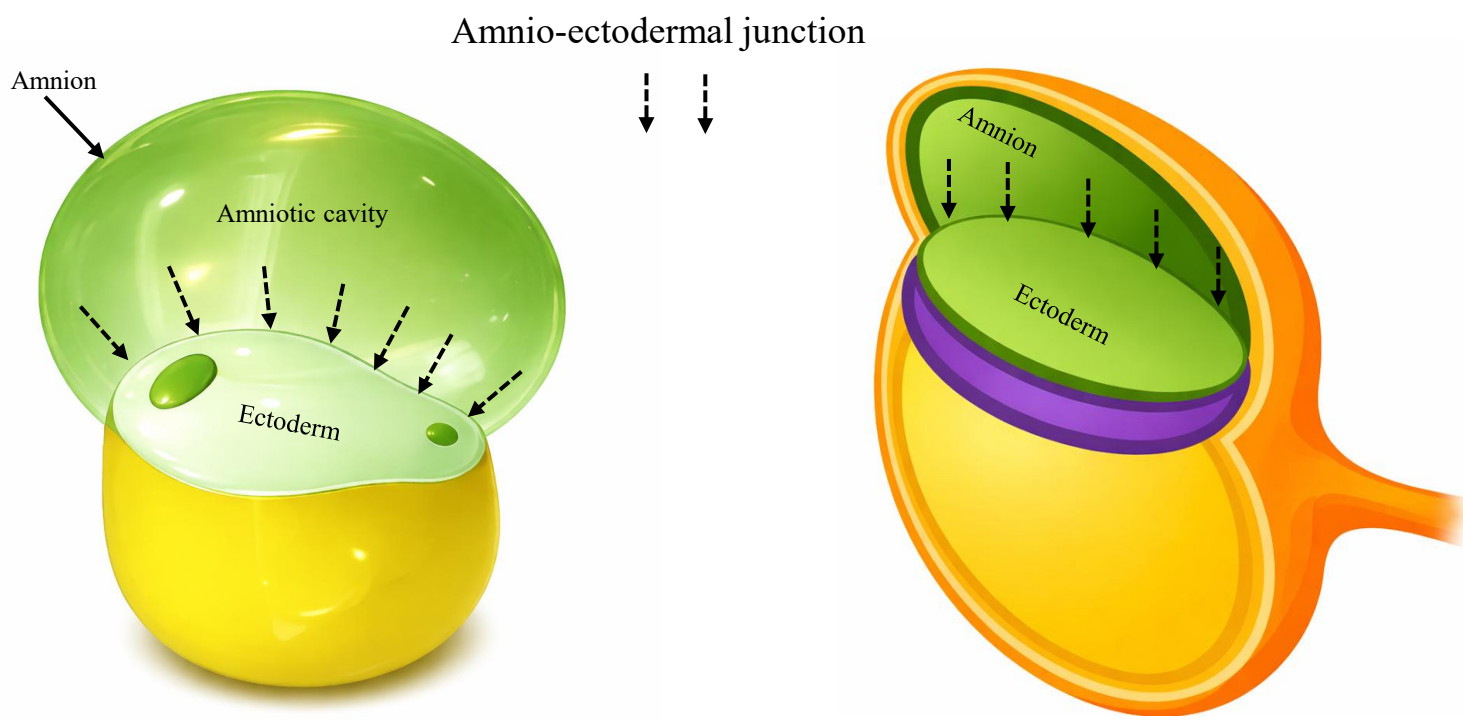
Thus, the floor of the amniotic cavity is formed by the epiblast, while the roof is formed by amnioblasts.

- ✓ By the 12th day, the amnioblasts become separated from the cytotrophoblast by extraembryonic mesoderm.

Note: In early development, the amnion is formed by amnioblasts, and later it consists of amnioblasts together with somatic extraembryonic mesoderm.



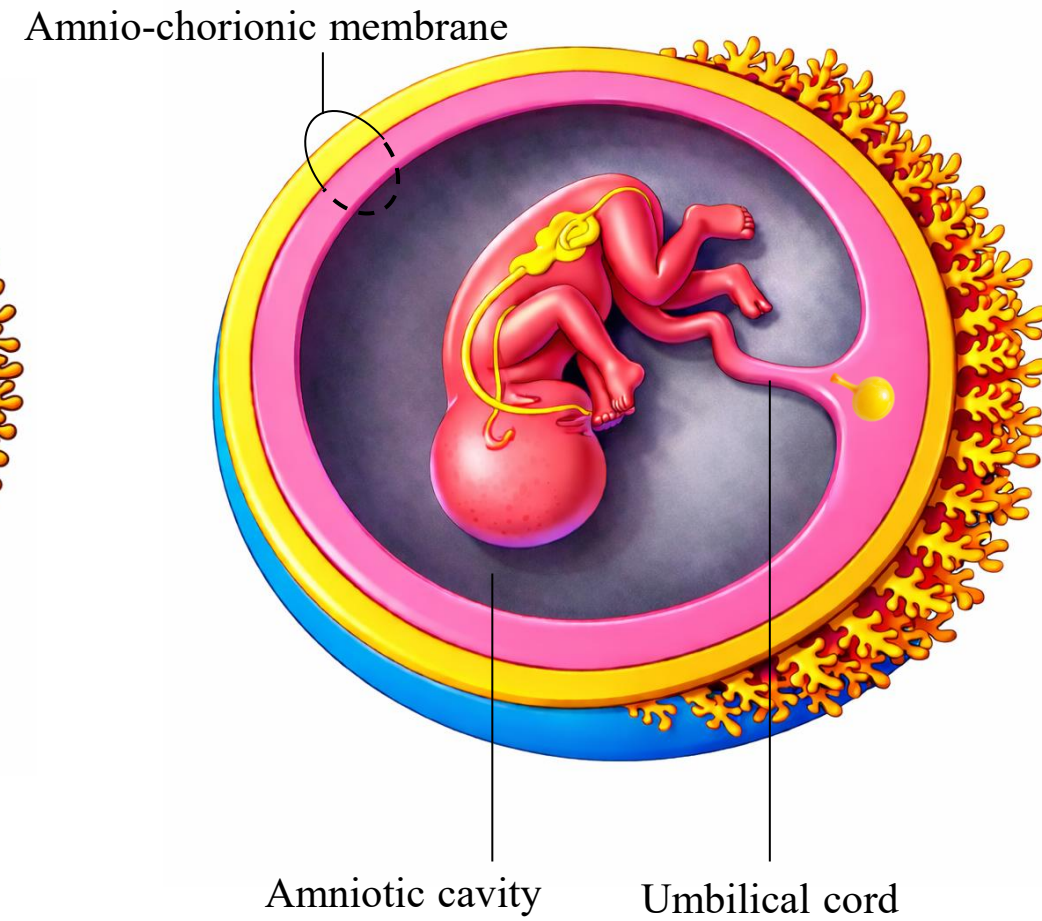
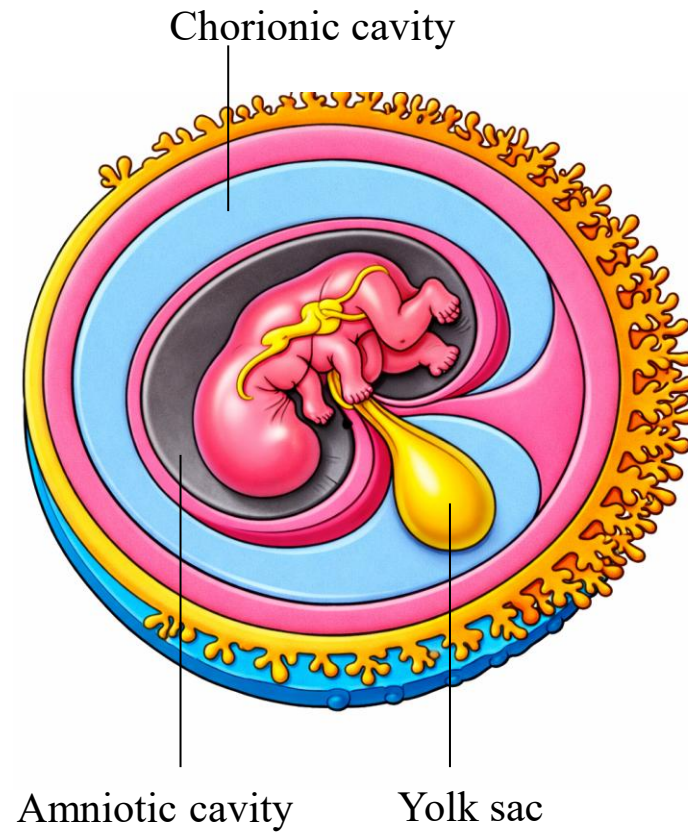
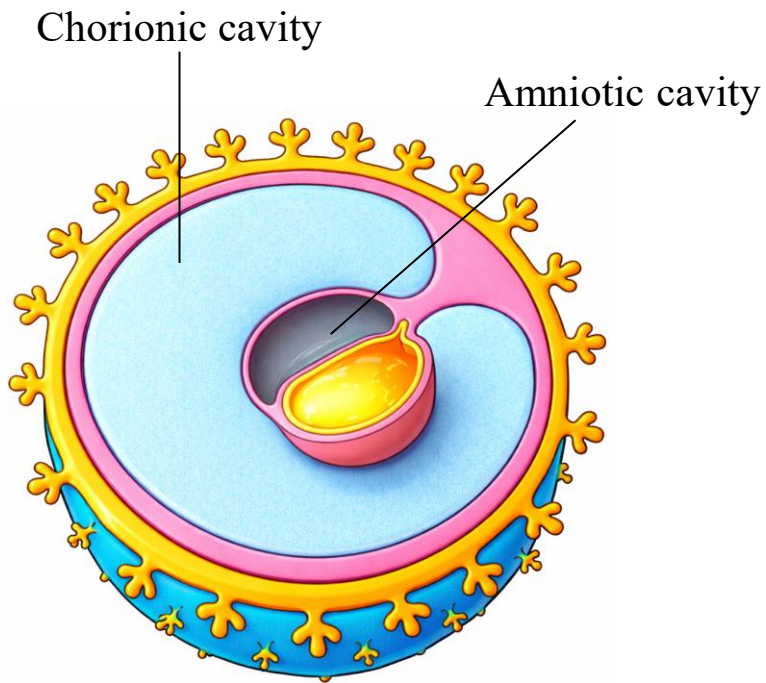
The amnion is a membrane. It is made of:
Amnioblasts (inner layer)
Extraembryonic somatic mesoderm (outer layer)



- ✓ The amnio-ectodermal junction is located at the margin of the oval embryonic disc during the 3rd week.

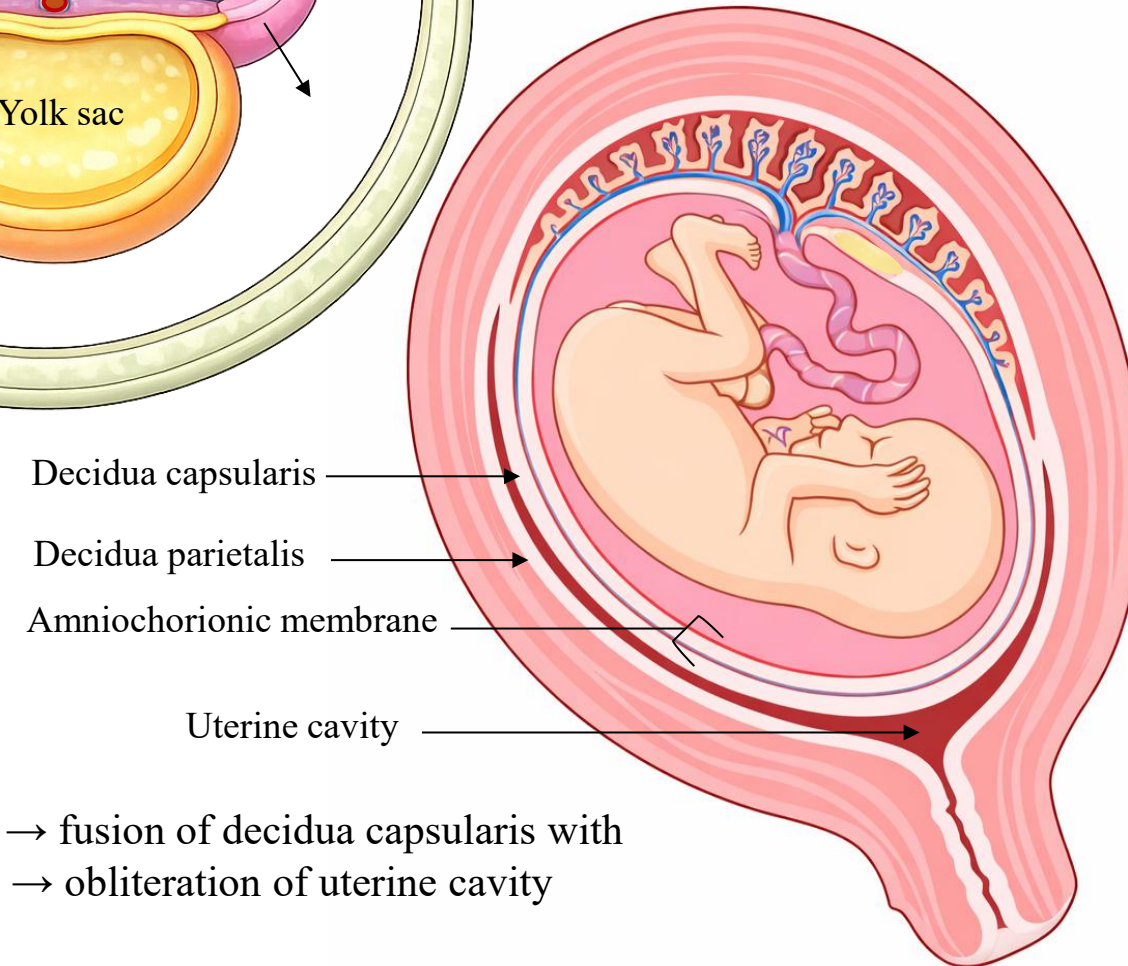
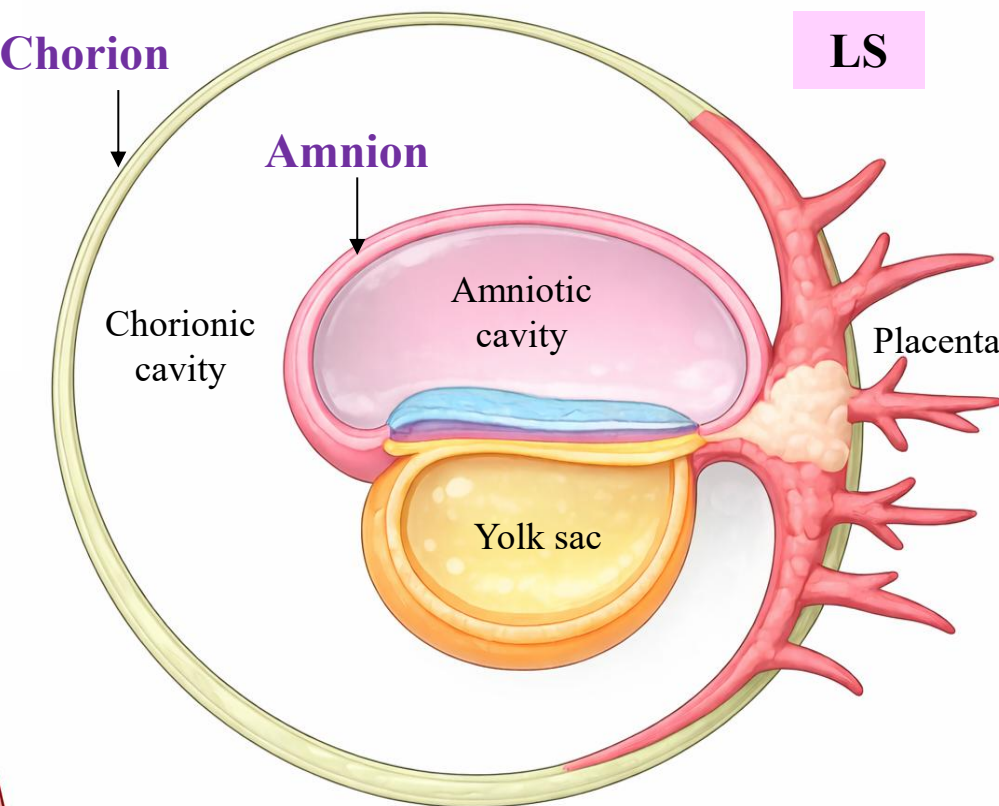
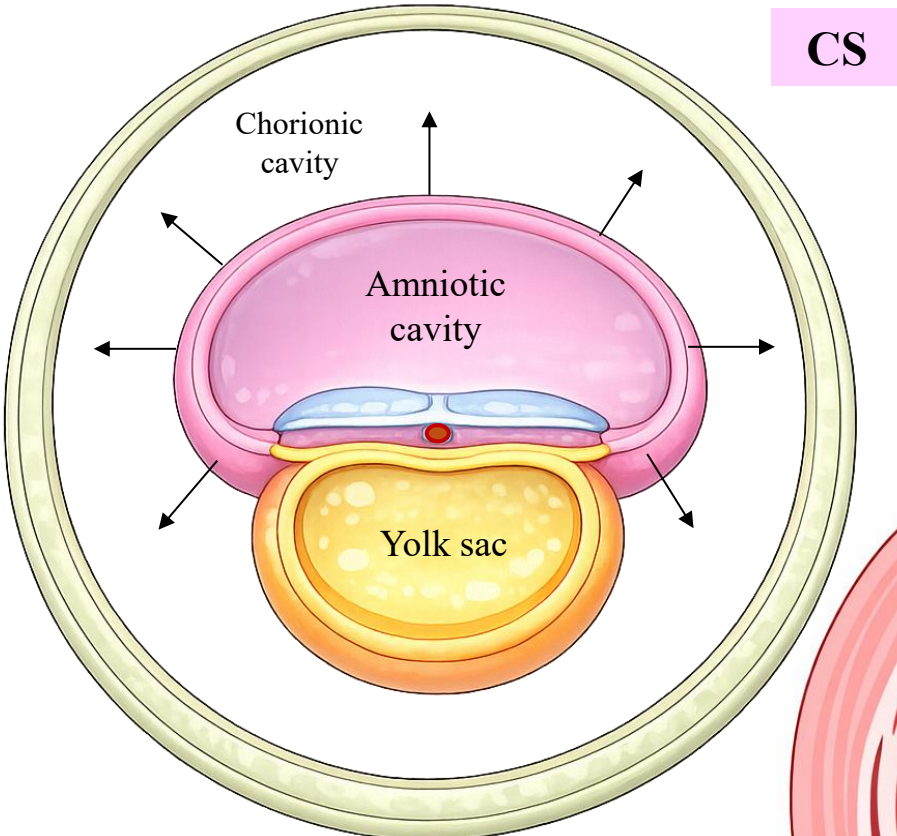
- ✓ During the 4th week, expansion of the amniotic cavity causes folding of the embryonic disc, and the amnio-ectodermal junction becomes located at the primitive umbilical ring (ventral).

Amnion & Folding



Later Changes

- ✓ The amnion comes into contact with the chorion, forming the amnio-chorionic membrane, with obliteration of the chorionic cavity.
- ✓ By the end of the 3rd month, the uterine cavity is obliterated due to expansion of the amniotic cavity.
- ✓ Finally, the amniotic cavity surrounds the fetus and forms a tubular sheath around the umbilical cord.

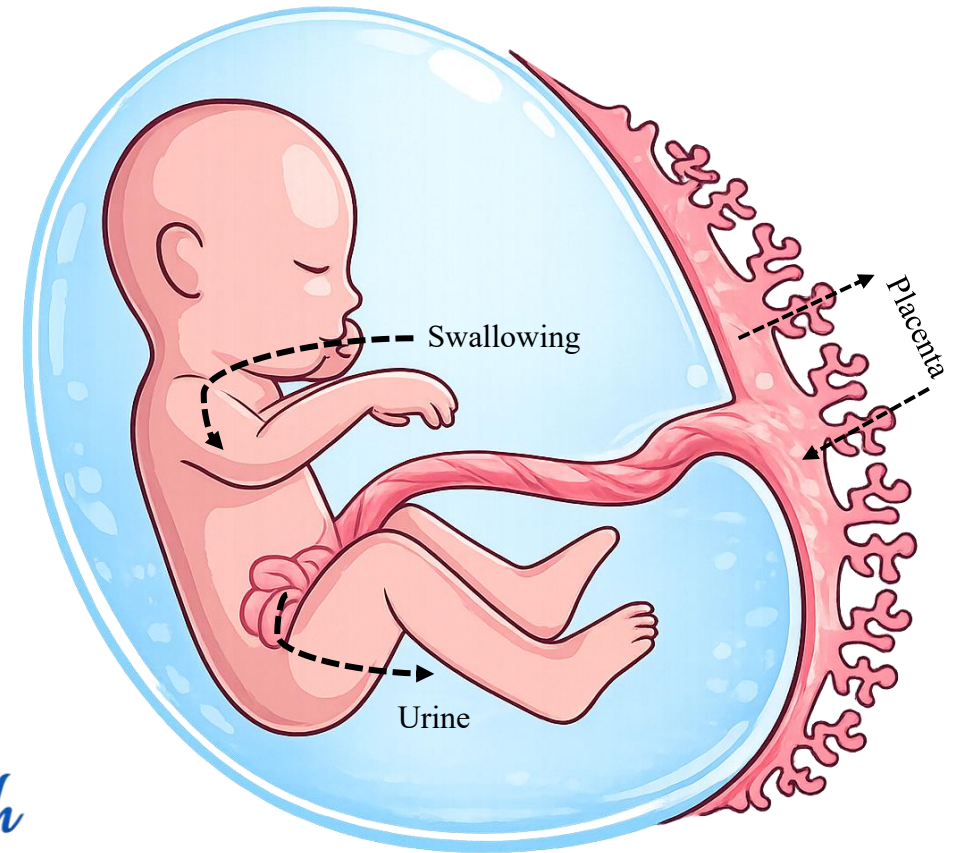
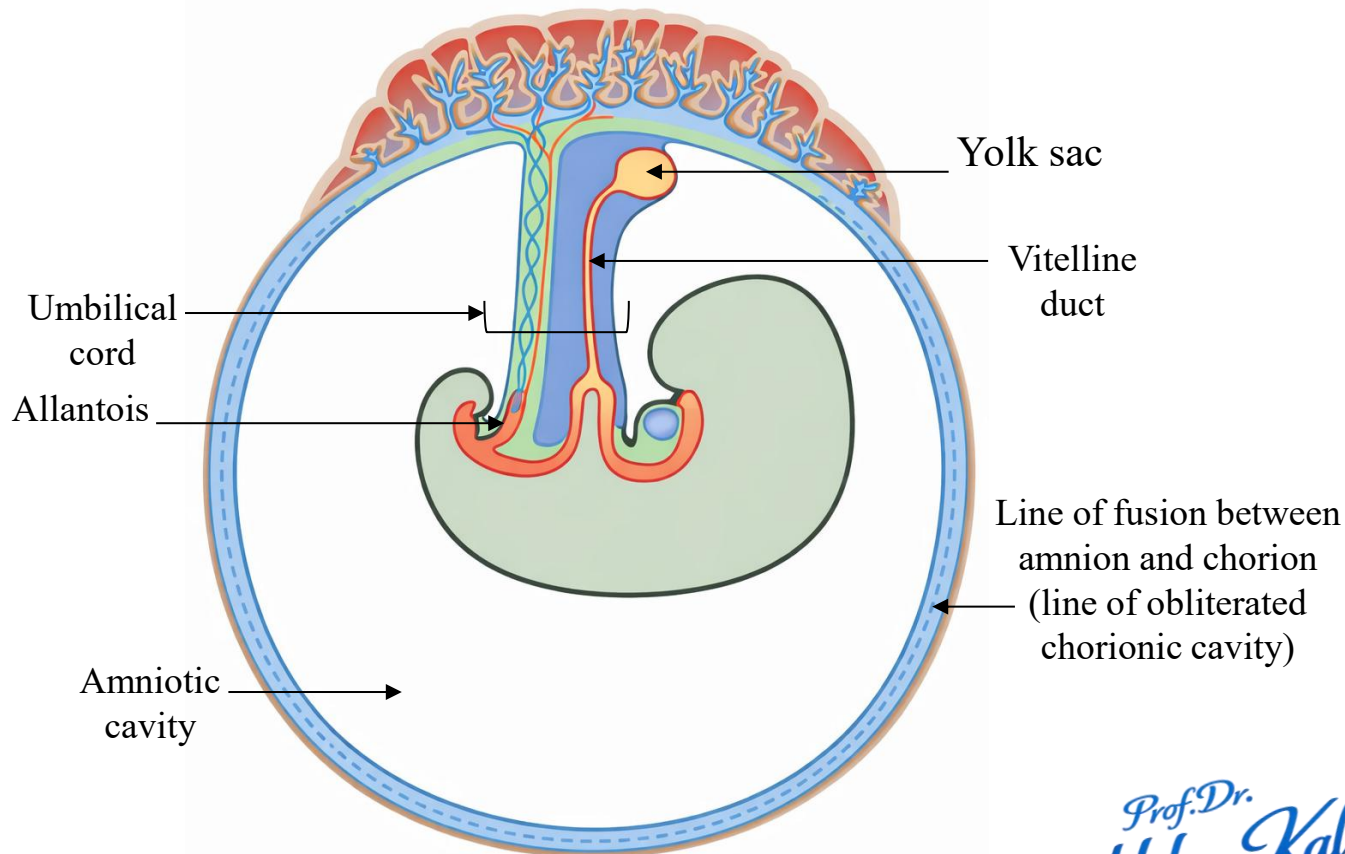


The amniotic sac enlarges and fuses with the chorionic sac during early embryonic development. This fusion occurs around week 8 of development, leading to the obliteration of the chorionic cavity and the formation of the amniochorionic membrane.

Expansion of amnion → fusion of decidua capsularis with decidua parietalis → obliteration of uterine cavity

Amniotic fluid

- ✓ **Normal volume:** at full term is about 800–1000 mL of a clear, watery fluid.
- ✓ **Source:**
 - Initially, it is derived from amnioblasts, and transport of fluid from the endometrium
 - Later in pregnancy, the main source is fetal urine (kidneys).
- ✓ **Circulation:** 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, or excreted as fetal urine.



*Prof. Dr.
Heba Kalbouneh*

Functions of amniotic fluid

During early pregnancy

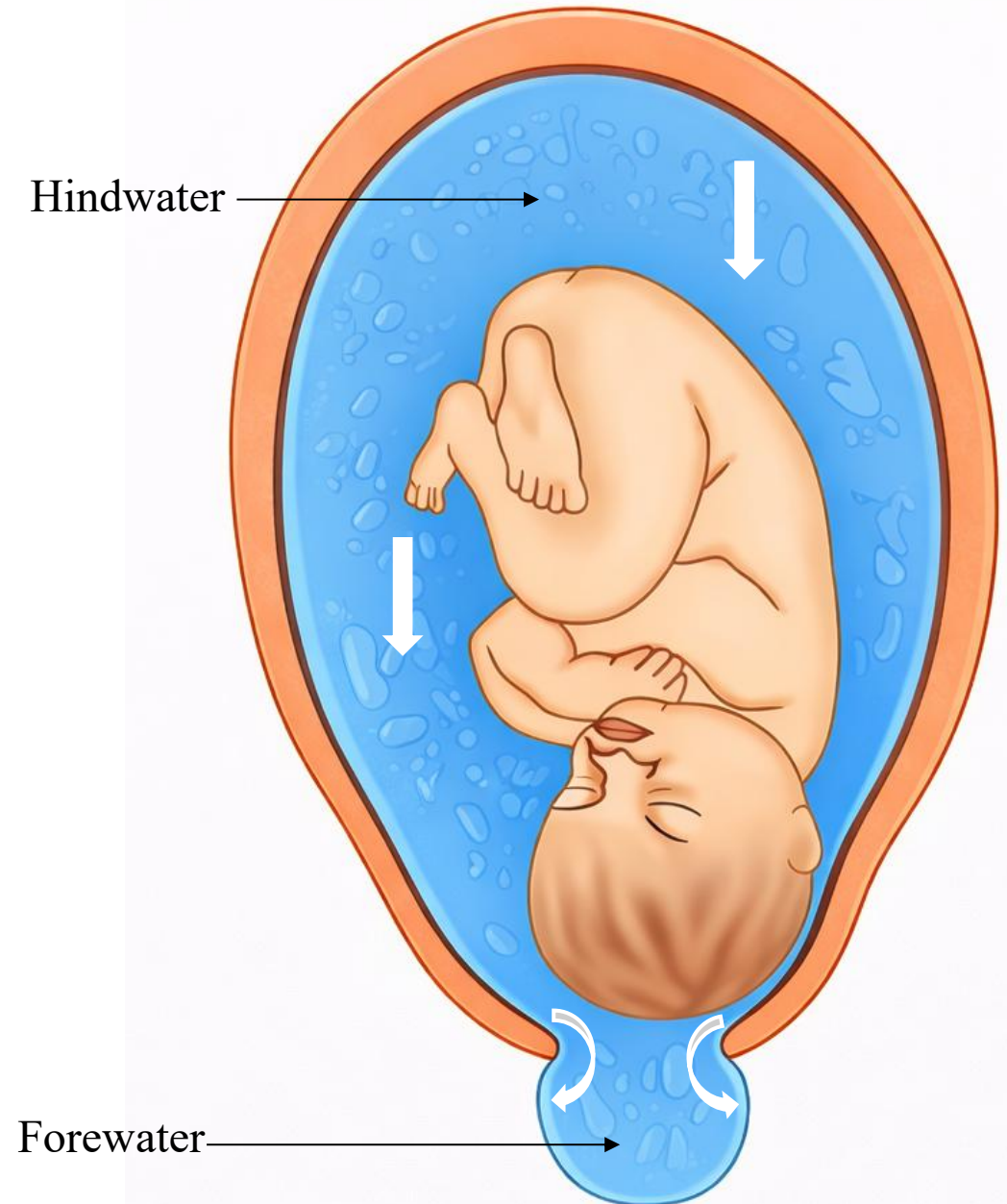
- Acts as a water cushion, absorbing external shocks.
- Acts as a heat insulator, maintaining a constant fetal temperature.
- Prevents adhesion of the embryo to the uterine wall.
- Prevents adhesion of fetal parts to each other.

During late pregnancy

- Provides a space for accumulation of fetal urine.
- Allows free fetal movements, which help in the development of muscles and joints.
- Facilitates swallowing, helping in the development of the gastrointestinal tract and training for suckling.

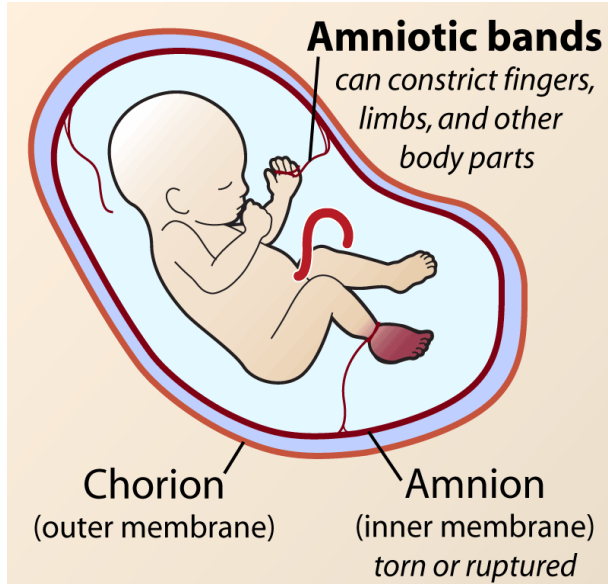
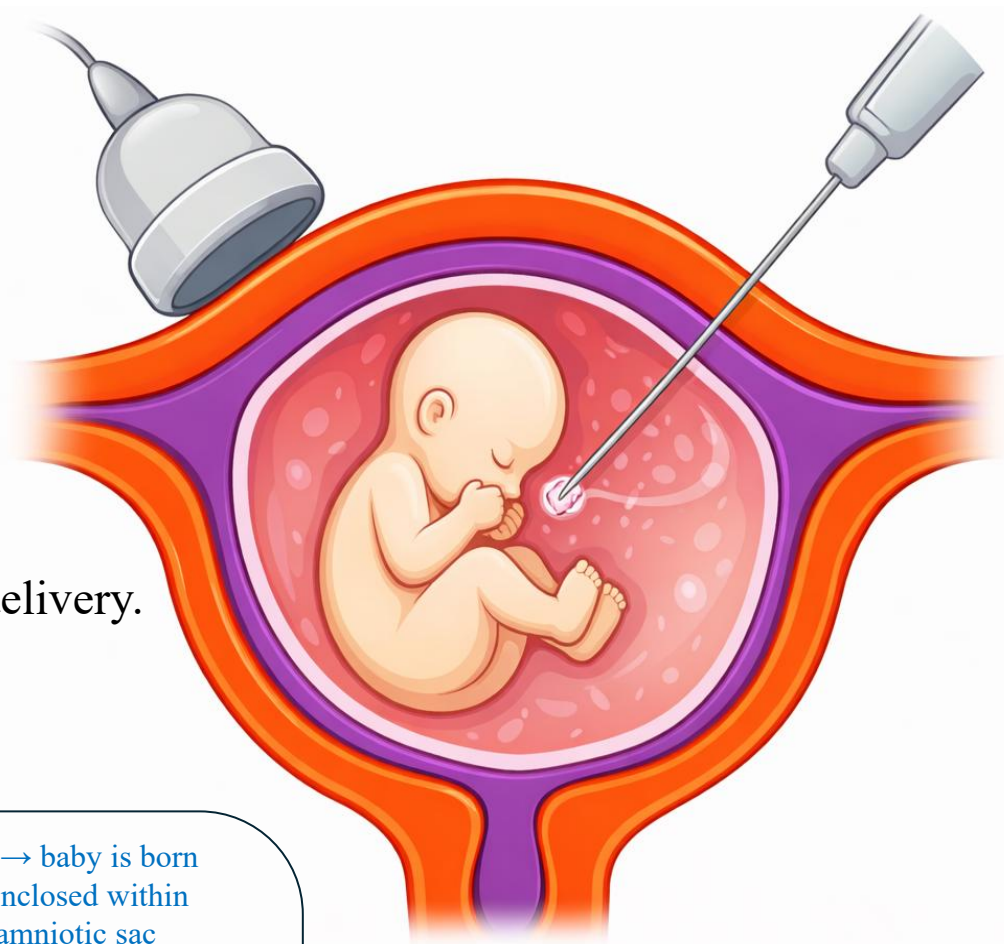
During labor

- Protects the fetus from uterine contractions.
- Forms the bag of waters, which helps in the gradual dilation of the cervix.
- Sterile amniotic fluid cleanses the vagina before passage of the baby (bacteriostatic).
- Rupture of the amniotic sac is a sign of the onset of labor.



Clinical applications

- ✓ **Amniocentesis:** is a prenatal diagnostic procedure in which a sample of amniotic fluid is obtained and analyzed for fetal cells, DNA, enzymes, and proteins to detect chromosomal abnormalities. Example: Down syndrome
- ✓ **Abnormal volumes:**
Oligohydramnios: amniotic fluid volume < 500 mL.
Polyhydramnios: amniotic fluid volume > 2000 mL.
- ✓ **Caul:** Occurs when the amniotic sac does not rupture completely during delivery.
- ✓ **Amniotic band adhesions:** usually occurs with cases of oligohydramnios



En caul birth → baby is born completely enclosed within the intact amniotic sac





En caul birth → baby is born completely enclosed within the intact amniotic sac

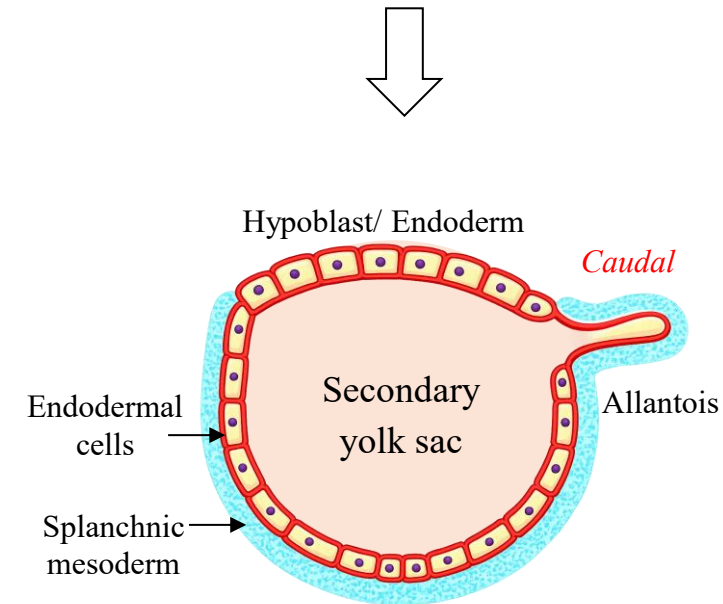
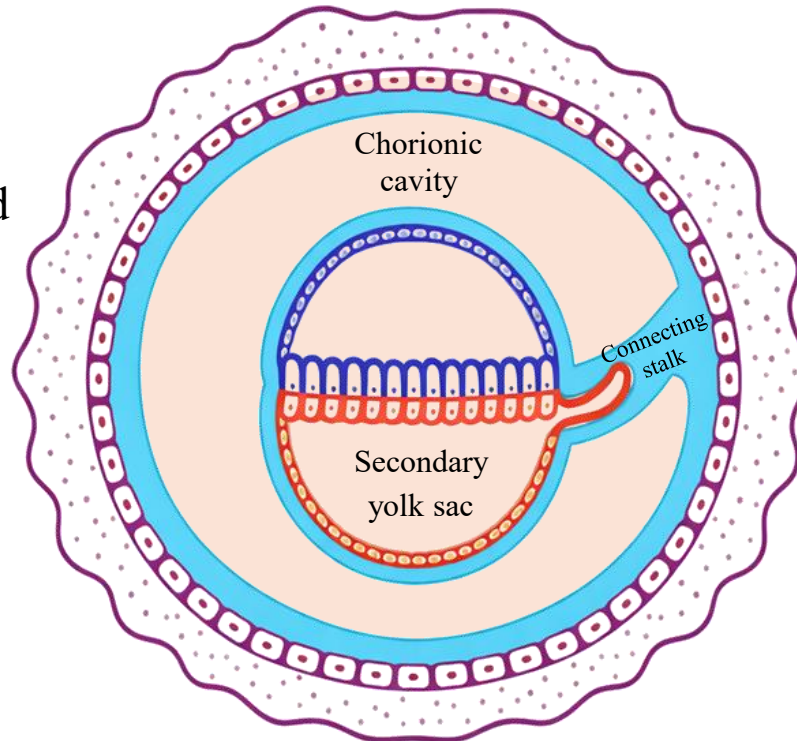
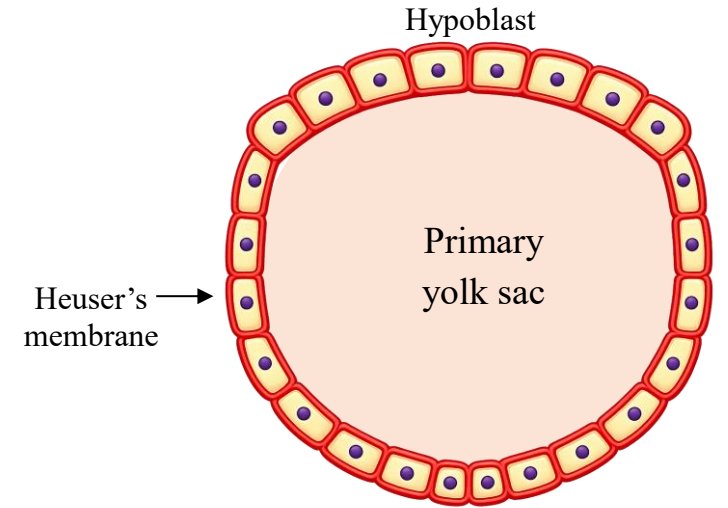
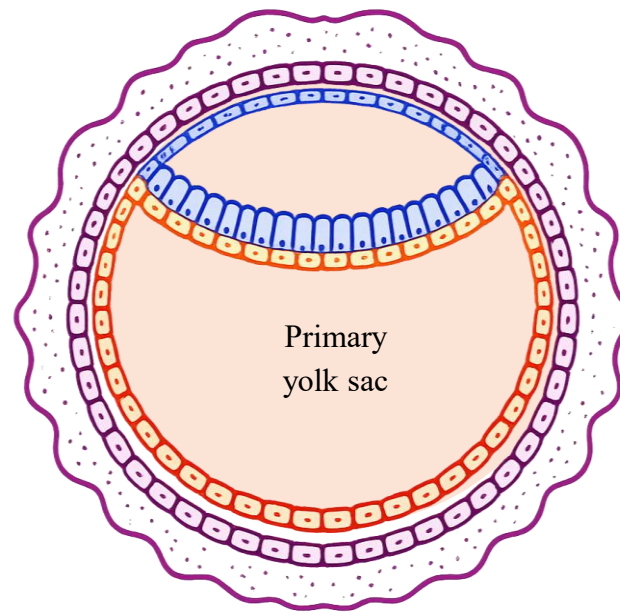
Yolk sac

Primary yolk sac

- ✓ Forms early in week 2
- ✓ Lined by Heuser's membrane
- ✓ Relatively large and temporary
- ✓ Soon partially pinched off as extraembryonic mesoderm develops

Secondary (definitive) yolk sac

- ✓ Forms when the primary yolk sac is remodeled and reduced
- ✓ Forms late in week 2
- ✓ Smaller, more stable structure
- ✓ The remaining functional yolk sac



Functions of the Yolk Sac

Early nutrition (first 2–3 weeks)

Transfers nutrients to the embryo before placental circulation is established.

Site of early hematopoiesis

First location of blood cell formation (blood islands) during week 3.

Source of primordial germ cells

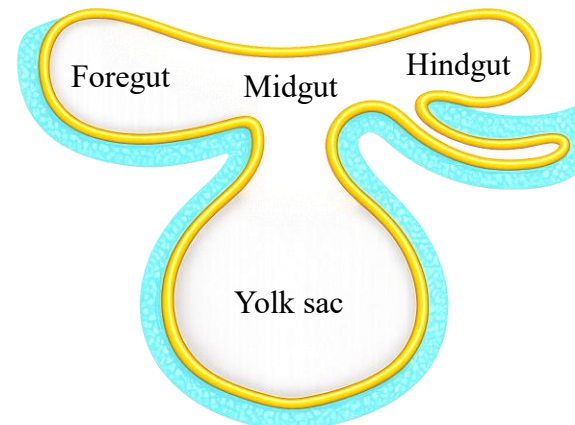
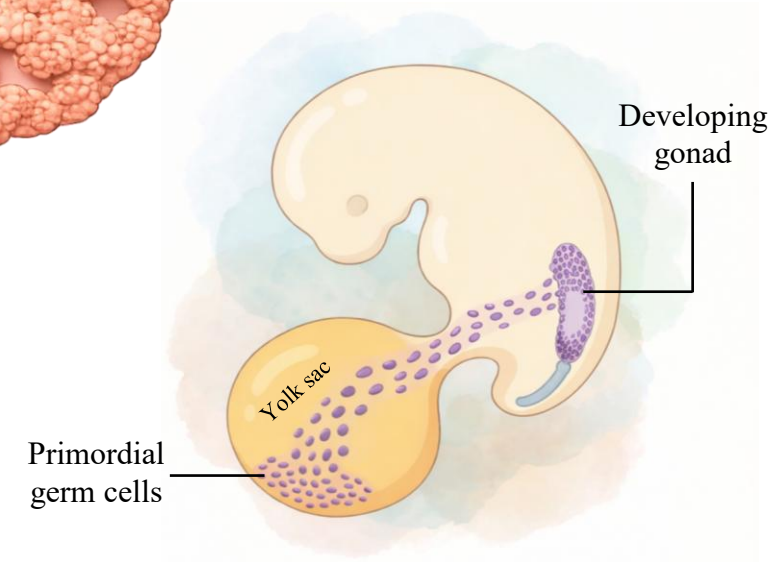
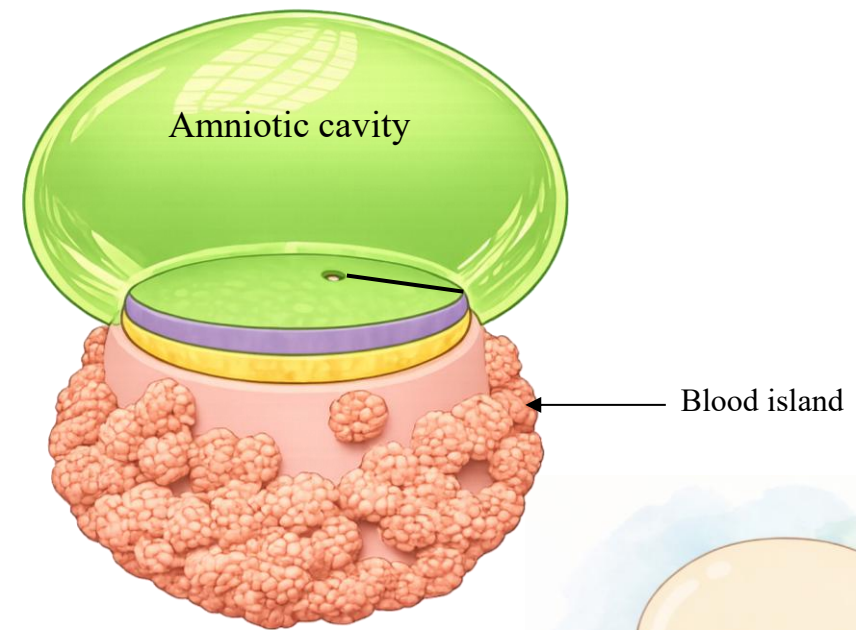
Germ cells originate in the yolk sac wall and later migrate to the gonads.

Contribution to gut formation

Incorporated into the embryo during folding to form the primitive gut (foregut, midgut and hindgut).

Formation of vitelline circulation

Gives rise to vitelline vessels.



Vitelline vessels are embryonic blood vessels that connect the **developing embryo** to the **yolk sac** and later contribute to major vessels of the gastrointestinal system.

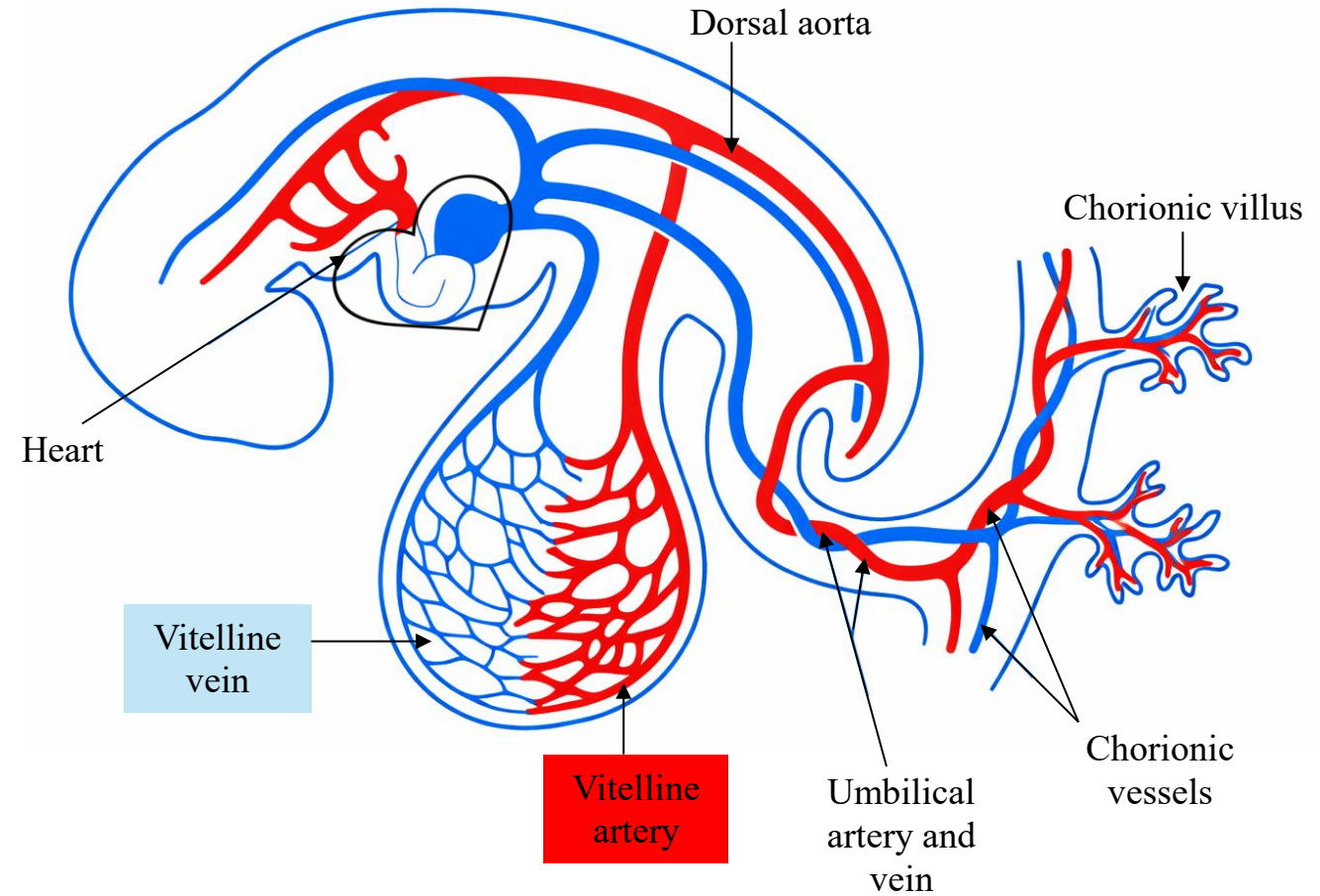
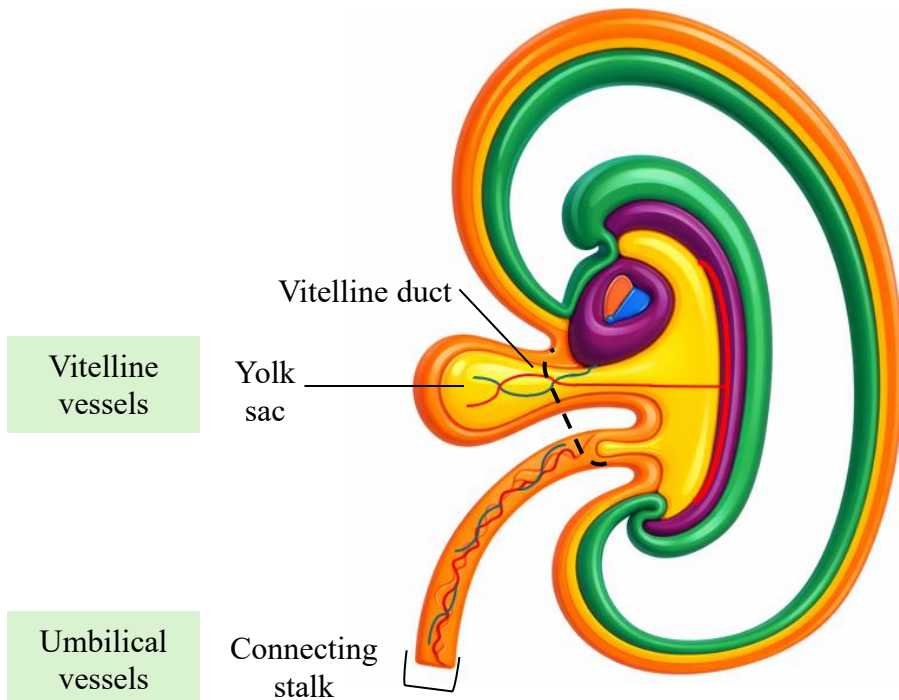
- ✓ Originate from the embryo
- ✓ Supply and drain the yolk sac

Vitelline vein

- Returns blood from the yolk sac to the embryonic heart

Vitelline artery

- Arises from the dorsal aorta



Vitelline = related to the yolk sac
*Latin word vitellus, which means **yolk***

Umbilical cord

It is the connection between placenta and fetus.

Length: 50 – 60 cm

Diameter: 2 cm.

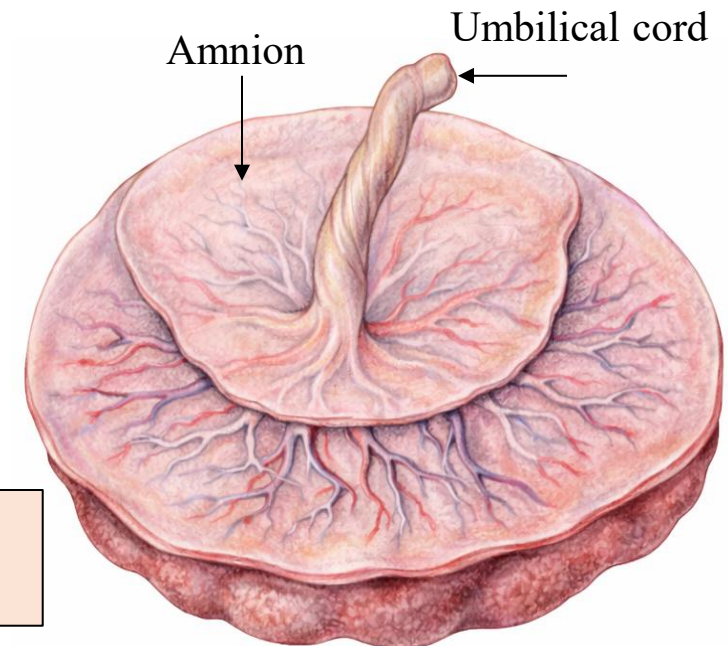
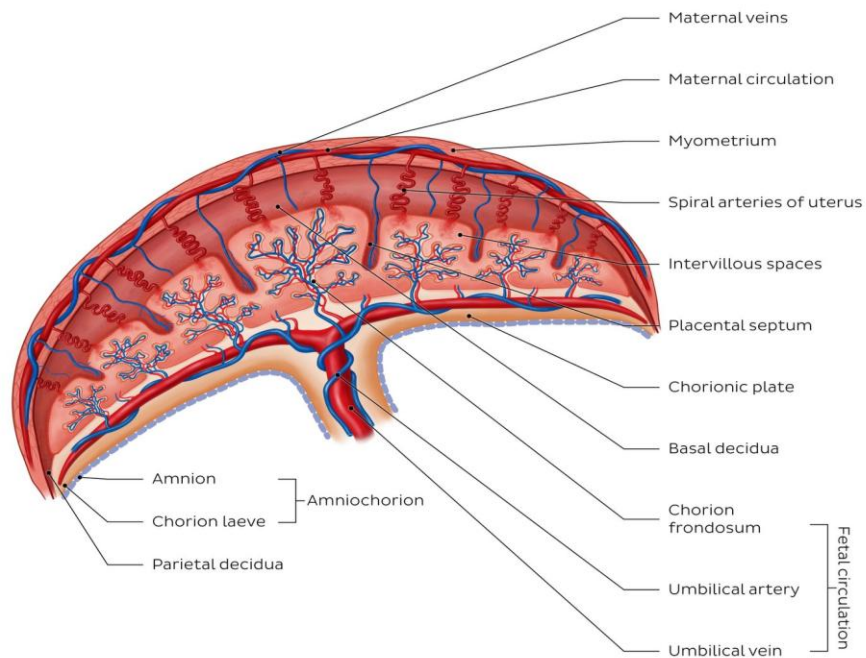
Shape: Tortuous, showing false knots..

Contents: 2 umbilical arteries, one umbilical vein embedded in Wharton's jelly and surrounded by amnion.

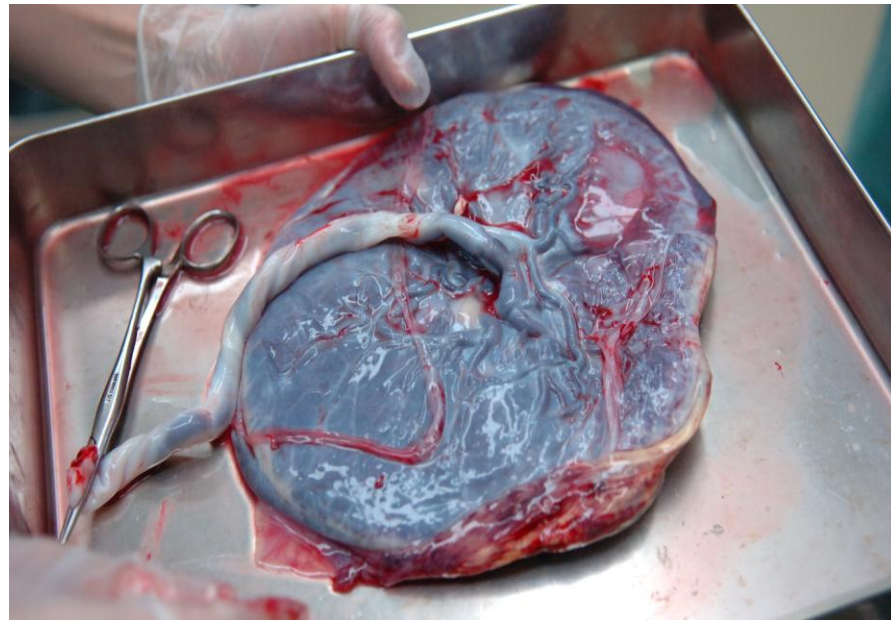
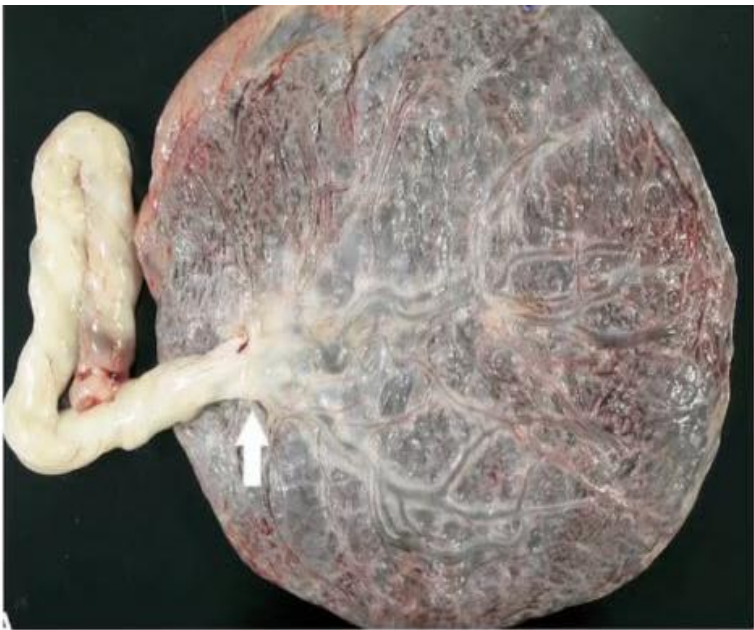
Attachments: It is attached to fetal surface of placenta near its center, the other attachment is to ventral aspect of fetal abdominal wall at the umbilicus.

Functions:

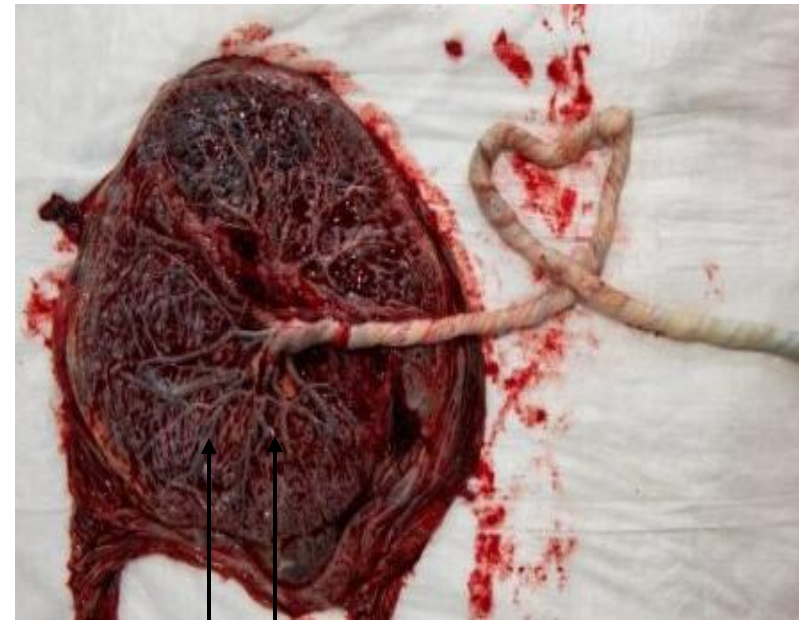
- It contains umbilical vessels that connect the fetus to the placenta.
- Allows free mobility of the fetus within the amniotic cavity.



Fetal surface of placenta



Fetal surface of placenta



Chorionic vessels

Fetal surface is covered with amnion and fetal blood vessels (chorionic vessels).
Umbilical cord is attached near the center of this surface.

Development of umbilical cord

- 1- Primitive umbilical ring.
- 2- Primitive umbilical cord.
- 3- Definitive umbilical cord.

During folding, the ventral body wall closes except at one site (one circular opening):
→ this opening is the **Primitive umbilical ring**

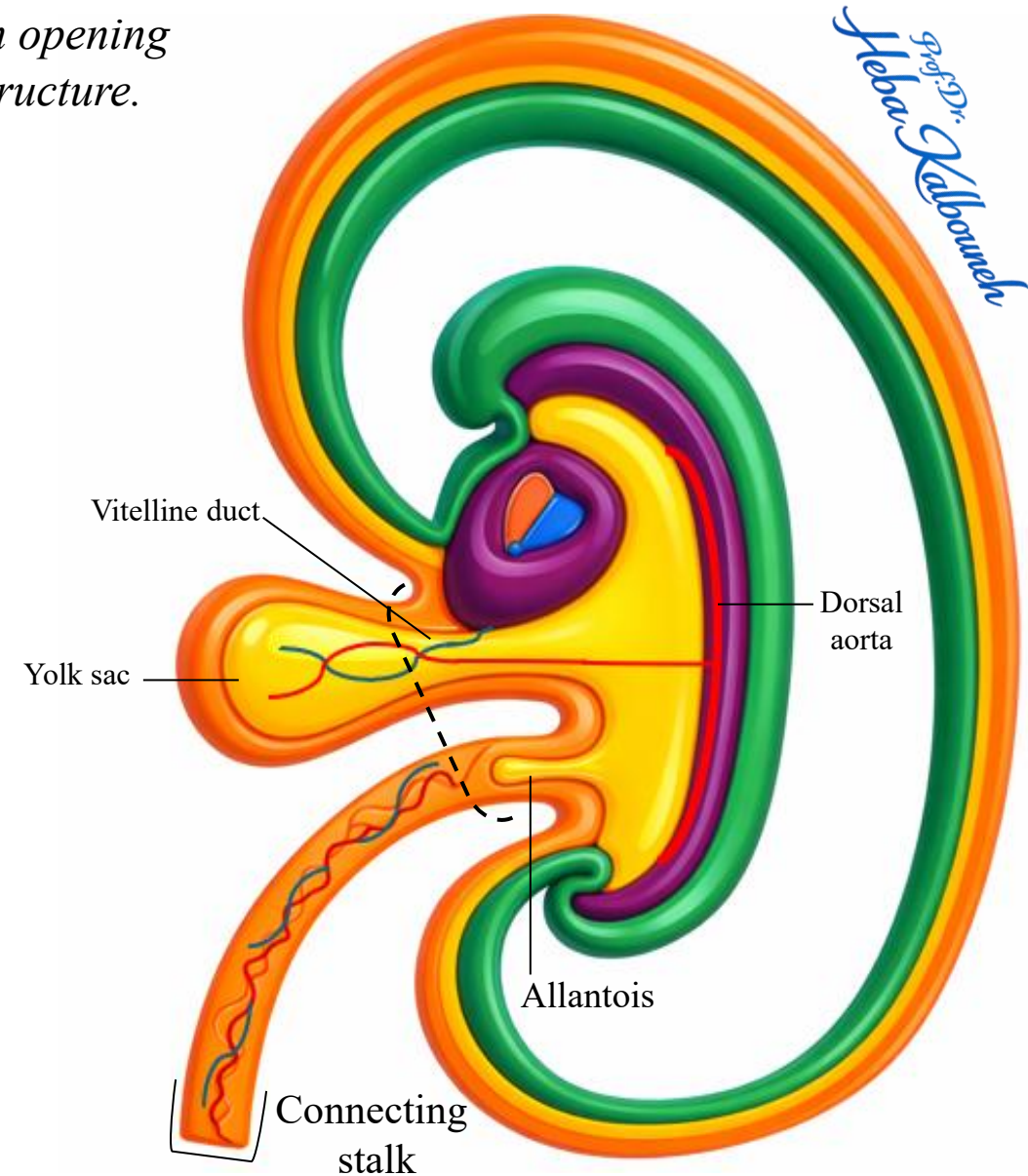
Through this ring pass:

- ✓ Vitelline duct (with vitelline vessels)
- ✓ Allantois (endoderm)
- ✓ Connecting stalk (containing umbilical vessels)

Note..... At this stage:

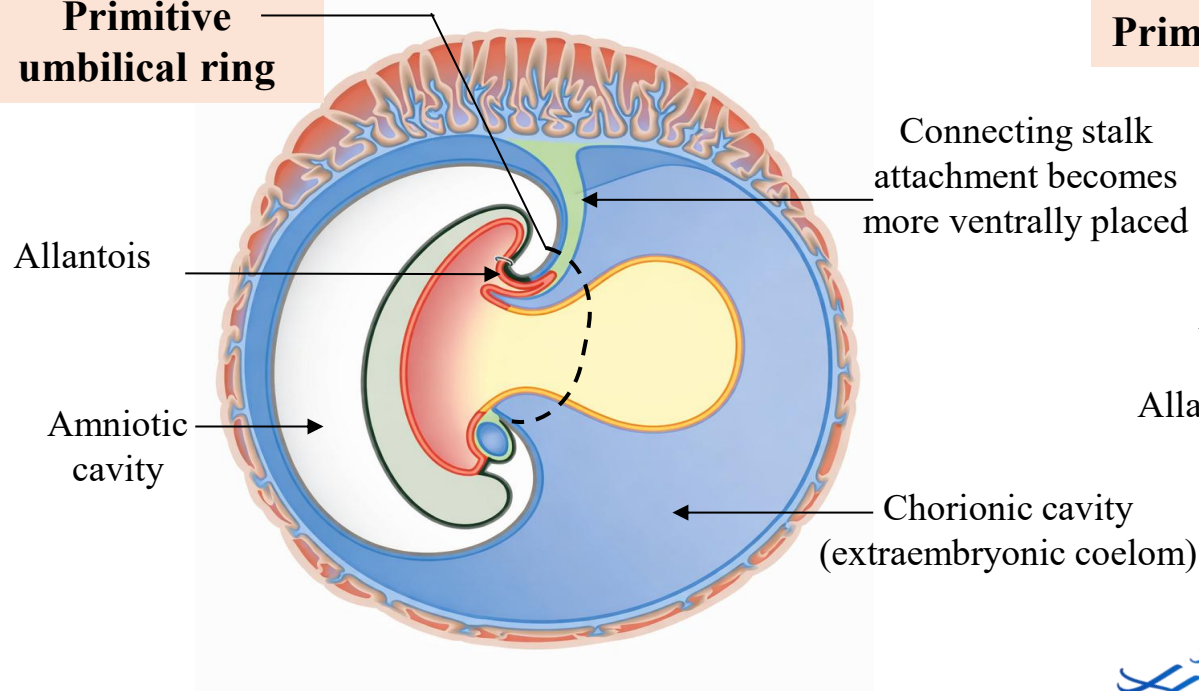
- ✓ It is simply an **opening in the ventral body wall**
- ✓ The structures are separate

*a transition from an opening
→ to a bundled structure.*

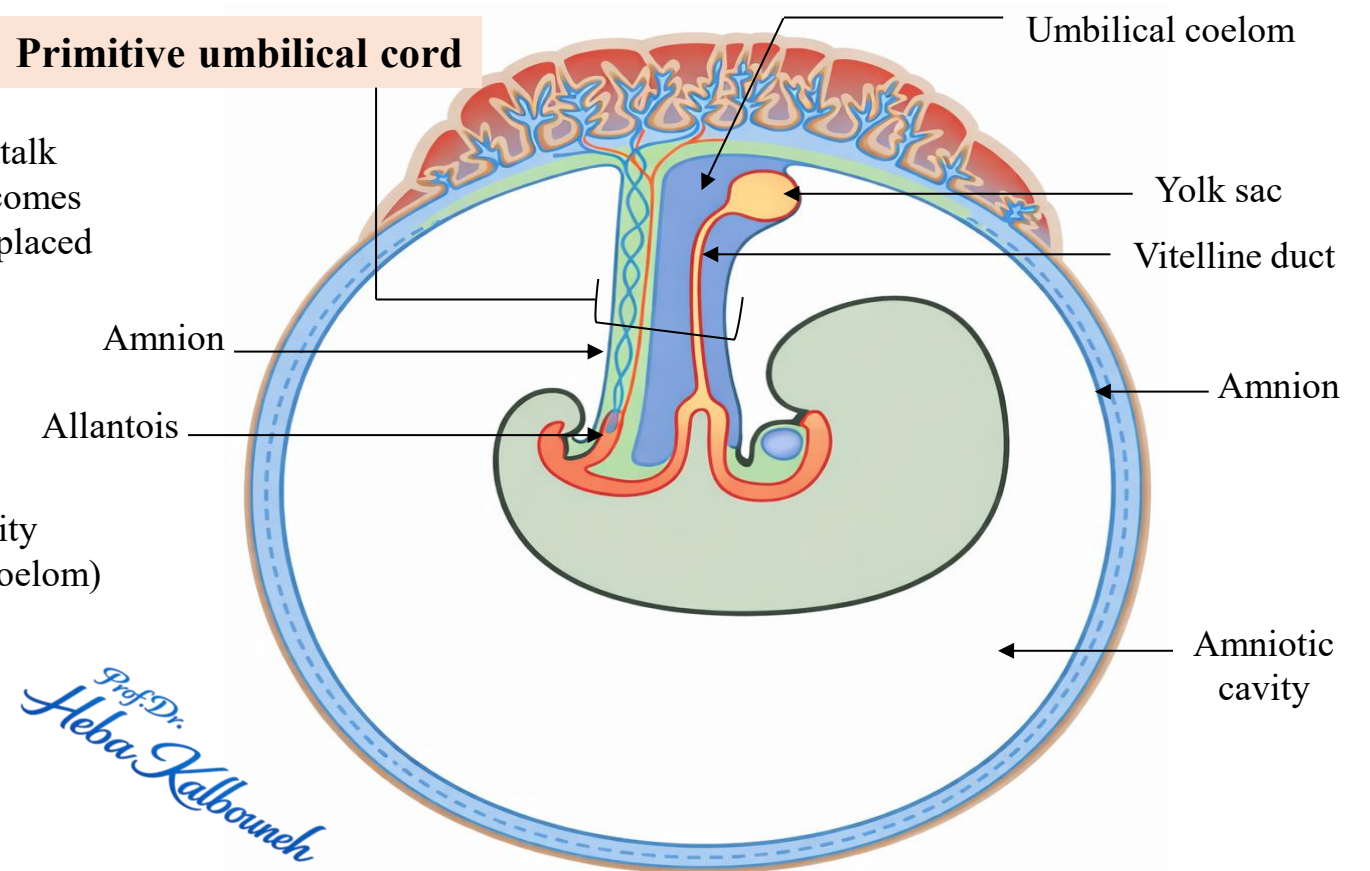


Note: Vitelline arteries and veins connect the yolk sac circulation to the dorsal aorta and embryonic heart.

Primitive umbilical ring



Primitive umbilical cord



Prof. Dr. Heba Kalbouneh

As development progresses:

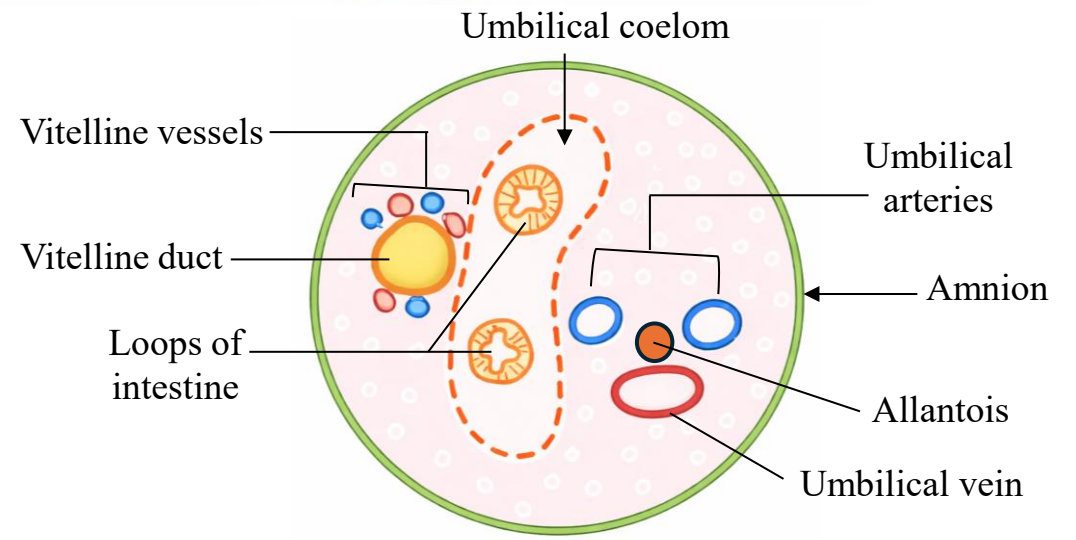
- ✓ The amniotic cavity enlarges rapidly
- ✓ The amnion begins to surround these structures externally

The amnion does not create new structures — it encloses existing ones (structures bundled together).

When the amnion envelops:

- ✓ Vitelline duct (with vitelline vessels)
- ✓ Allantois
- ✓ Connecting stalk (containing umbilical vessels)

These structures become enclosed together within a common covering
Now they form a single cylindrical structure 🖱️ **Primitive umbilical cord**



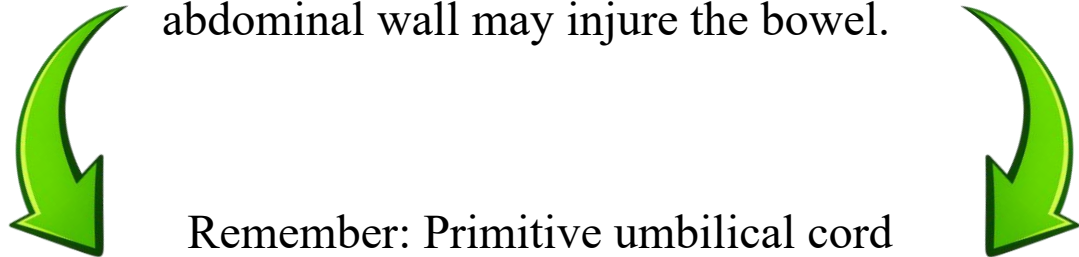
The rapidly elongating midgut undergoes physiological herniation into the umbilical cord during the 6th week of development. Around the 10th week, the intestinal loops return to the abdominal cavity.

What happens during physiological herniation? (Week 6–10)

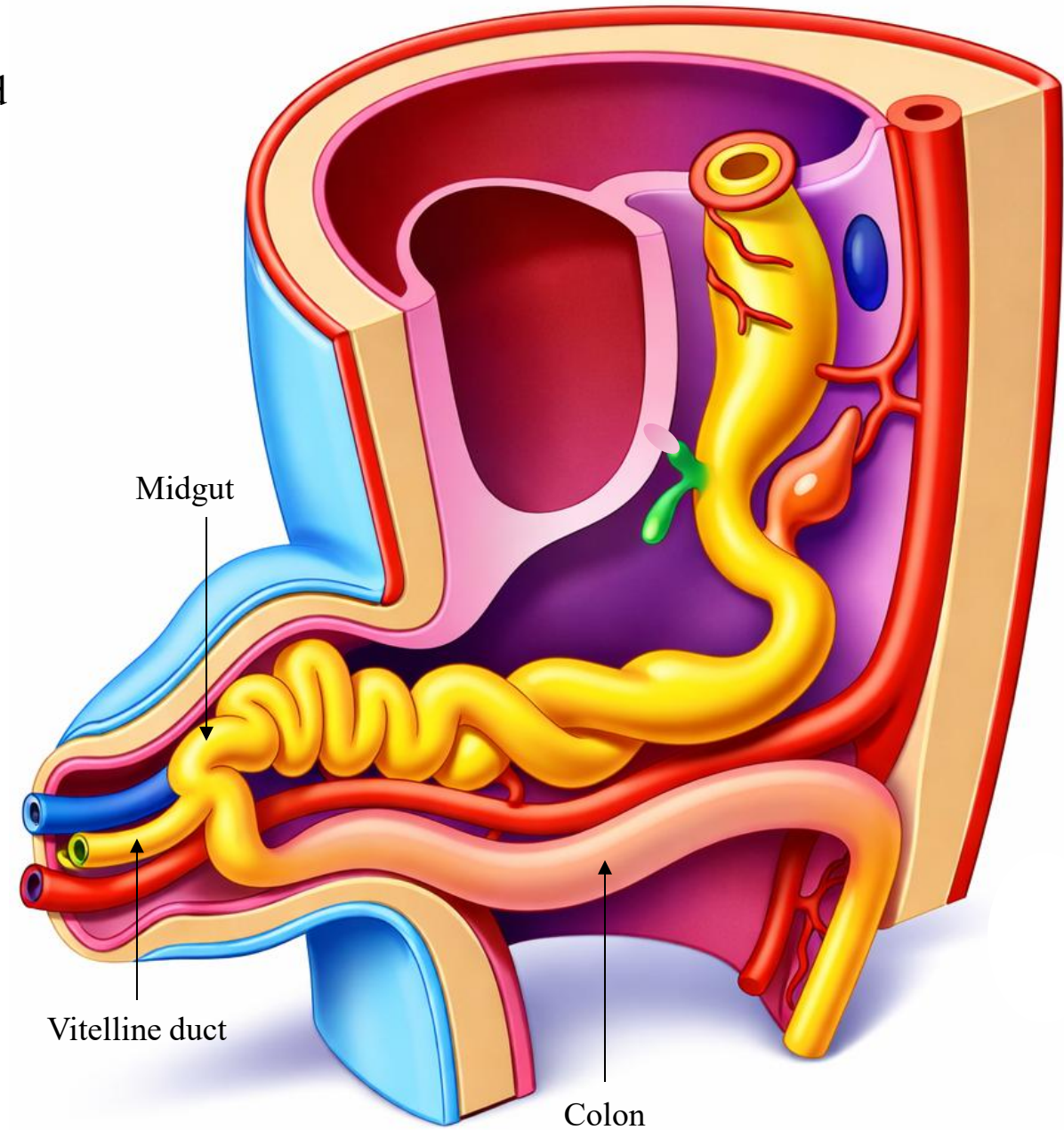
- ✓ Rapid elongation of midgut
- ✓ Liver enlarges
- ✓ Abdominal cavity temporarily too small
- ✓ Midgut herniates into the umbilical cord

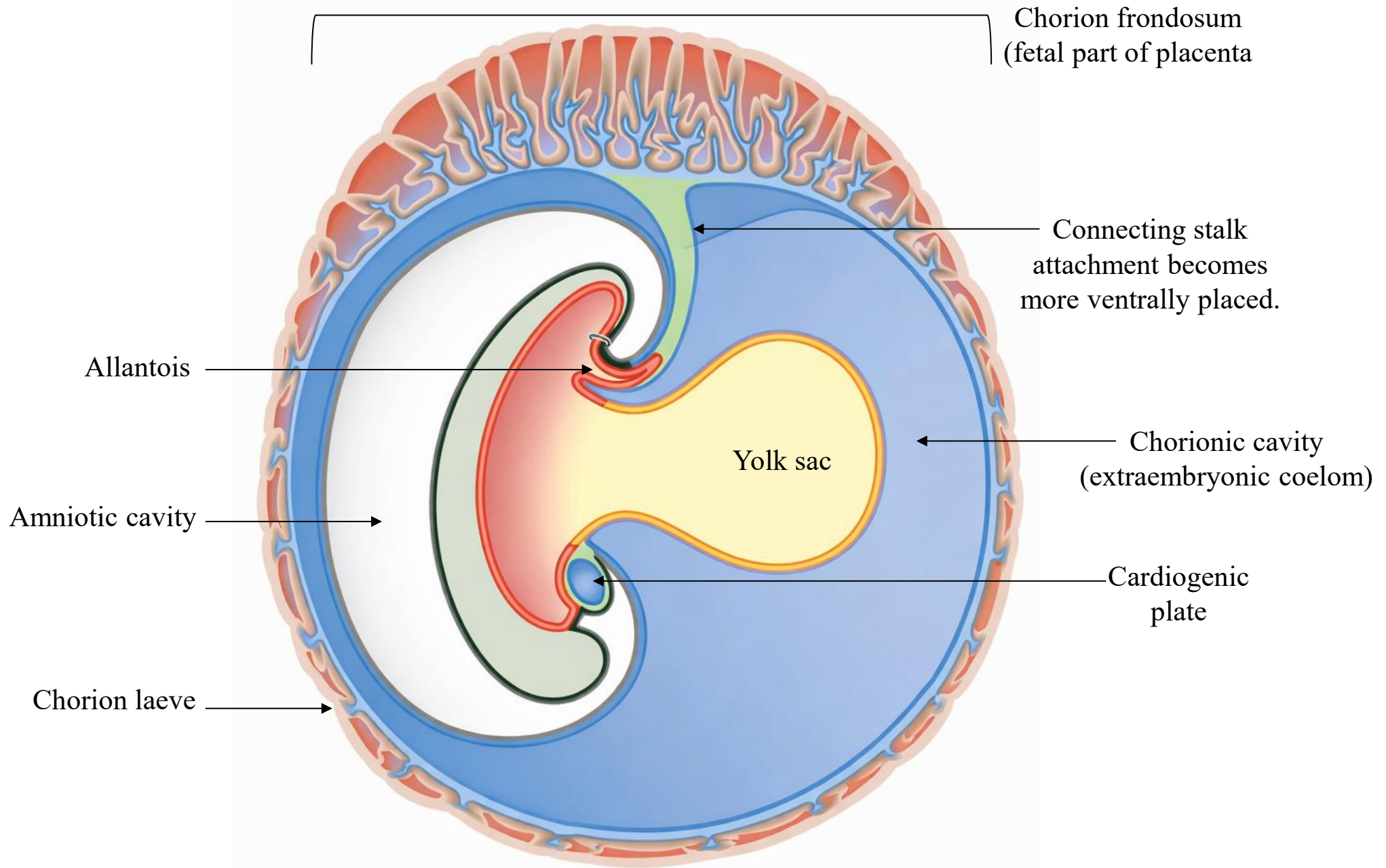
Correct site of ligation of the umbilical cord !!!

Proper ligation of the umbilical cord is important because, in rare cases, the cord may still contain intestinal loops, and clamping too close to the abdominal wall may injure the bowel.



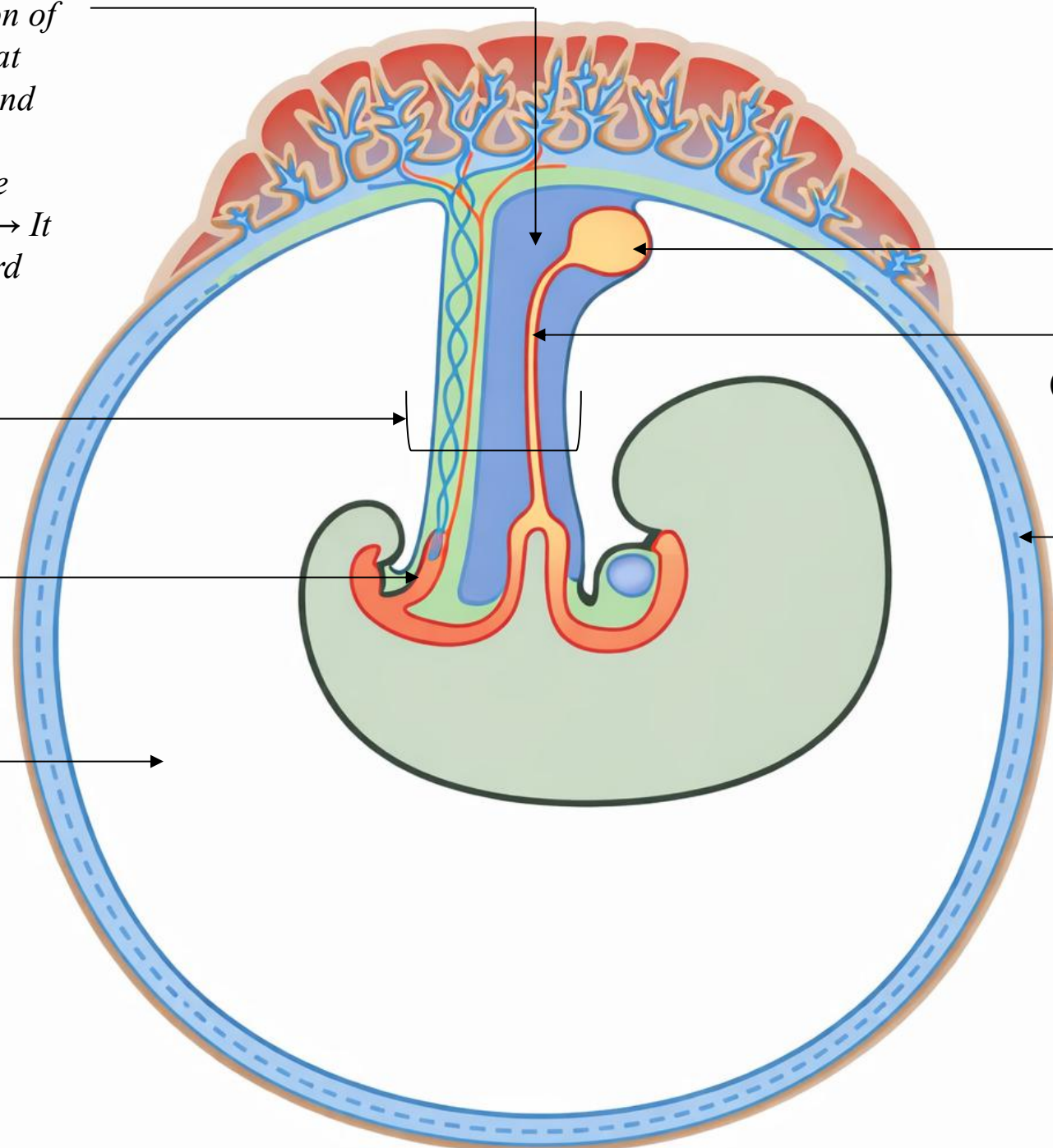
Remember: Primitive umbilical cord contains a loop of intestine in its proximal part (physiological herniation)





Umbilical coelom is the extension of the extraembryonic coelom that envelops the connecting stalk and vitelline duct (yolk stalk).

It disappears gradually as the definitive umbilical cord forms → It becomes obliterated as the cord becomes compact



Yolk sac

Vitelline duct
(connection to yolk sac)

Line of fusion
between amnion and
chorion (line of
obliterated chorionic
cavity)

Primitive
umbilical cord

Allantois

Amniotic cavity

Definitive umbilical cord

It is the line of life for the fetus

✓ The definitive umbilical cord is the **mature vascular connection** between the fetus and the placenta.

The definitive umbilical cord consists of:

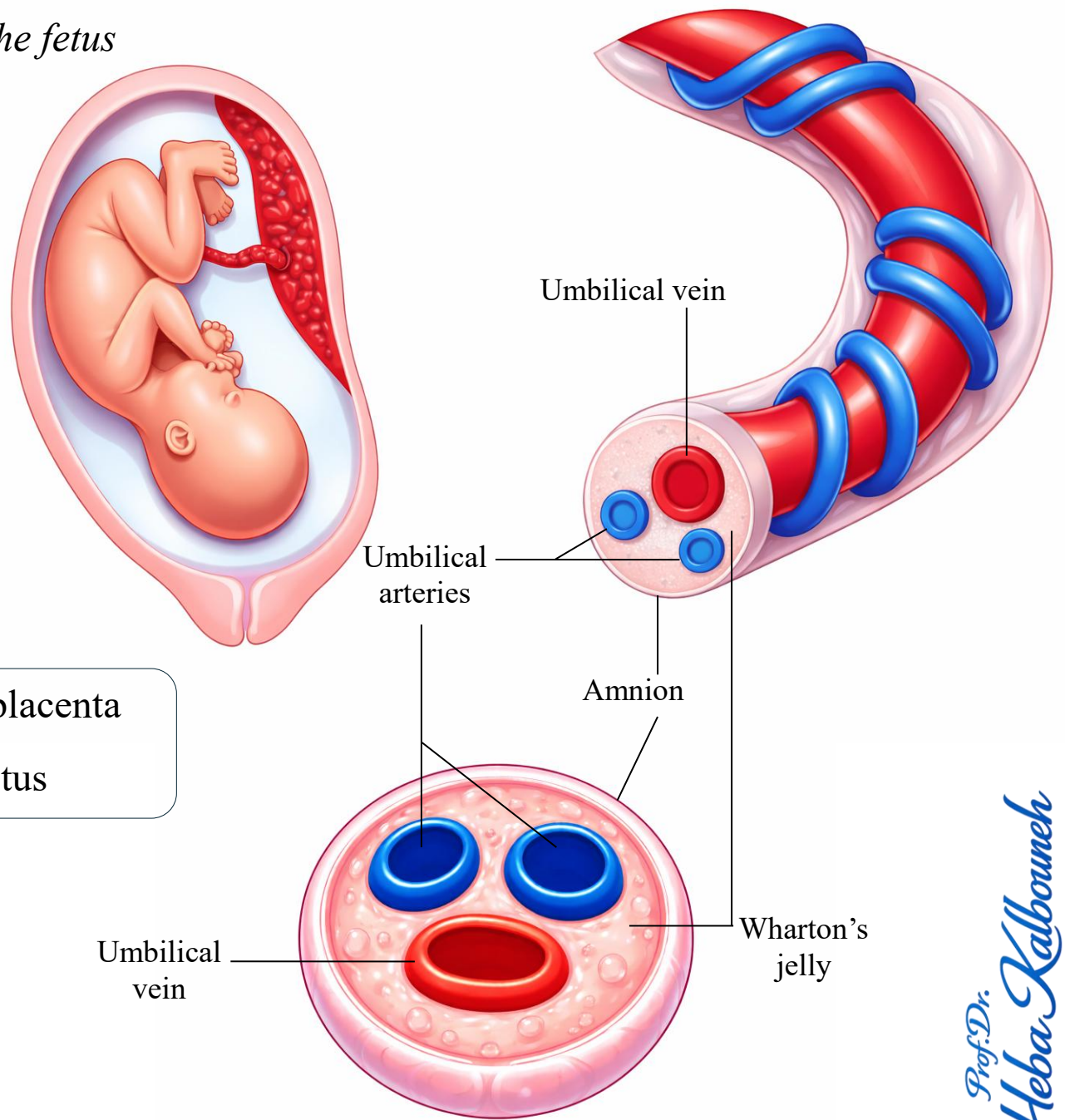
- 2 umbilical arteries
 - 1 umbilical vein
 - Wharton's jelly
- Covered by amnion

Umbilical arteries → carry deoxygenated blood from fetus to placenta

Umbilical vein → carries oxygenated blood from placenta to fetus

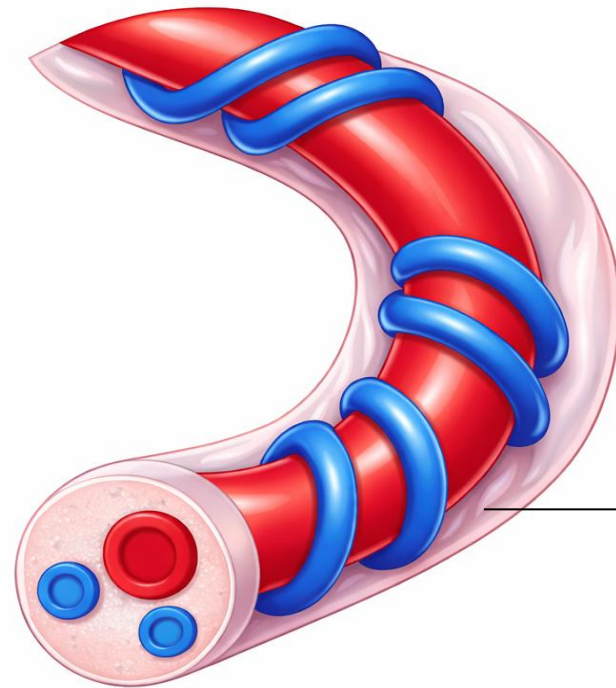
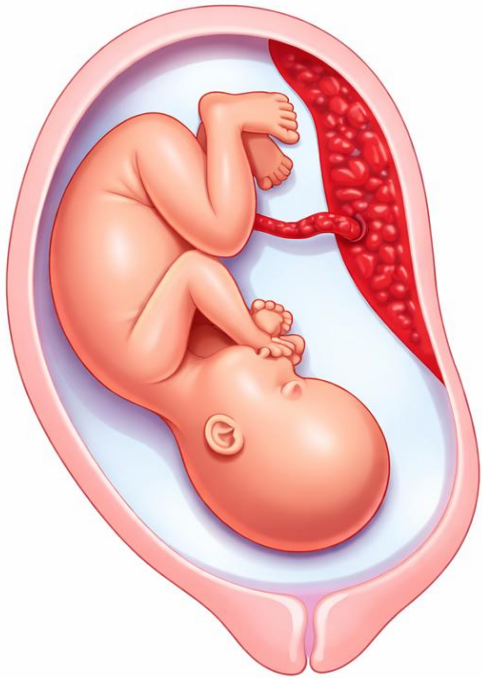
Note: the definitive umbilical cord may contain:

- Remnant of allantois (urachus)
 - Rare remnants of vitelline duct
 - Remnants of extraembryonic coelom ????
- These are usually obliterated.

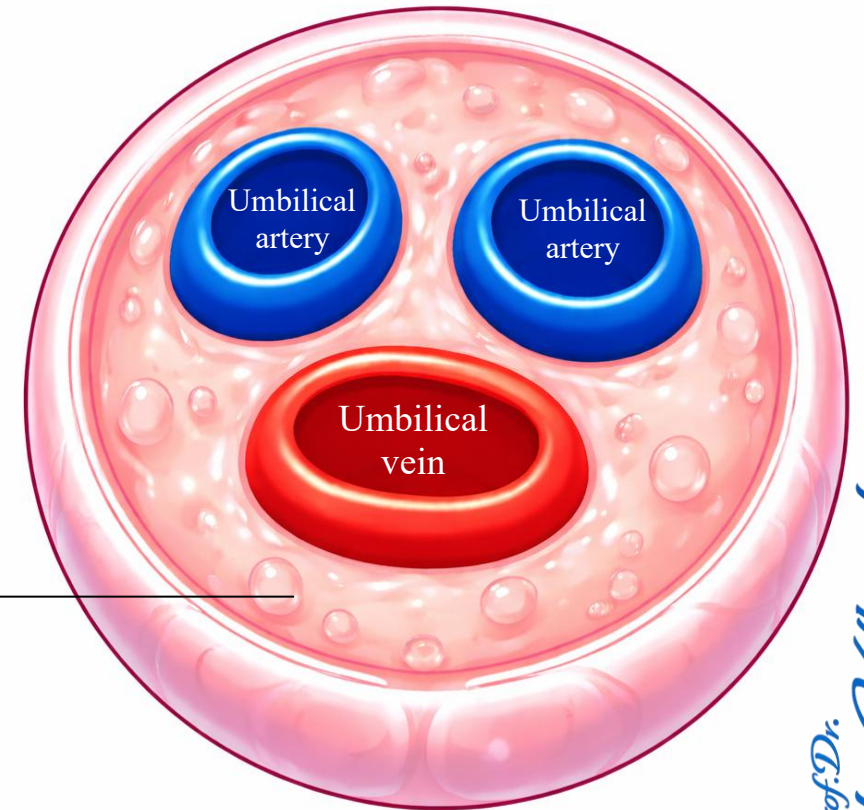


Wharton's Jelly

- ✓ Mucoïd connective tissue
- ✓ Derived from extraembryonic mesoderm (connecting stalk)
- ✓ Rich in proteoglycans
- ✓ Provides:
 - Cushioning
 - Protection against compression
 - Flexibility
- ✓ This prevents vascular collapse.

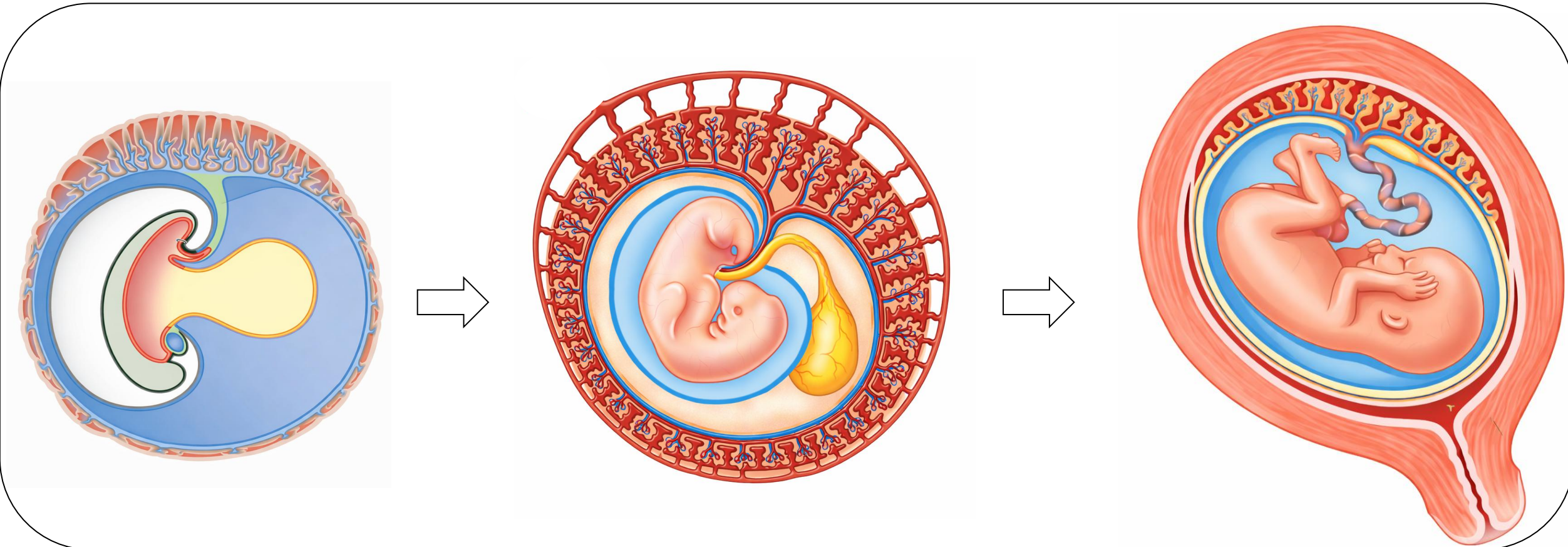


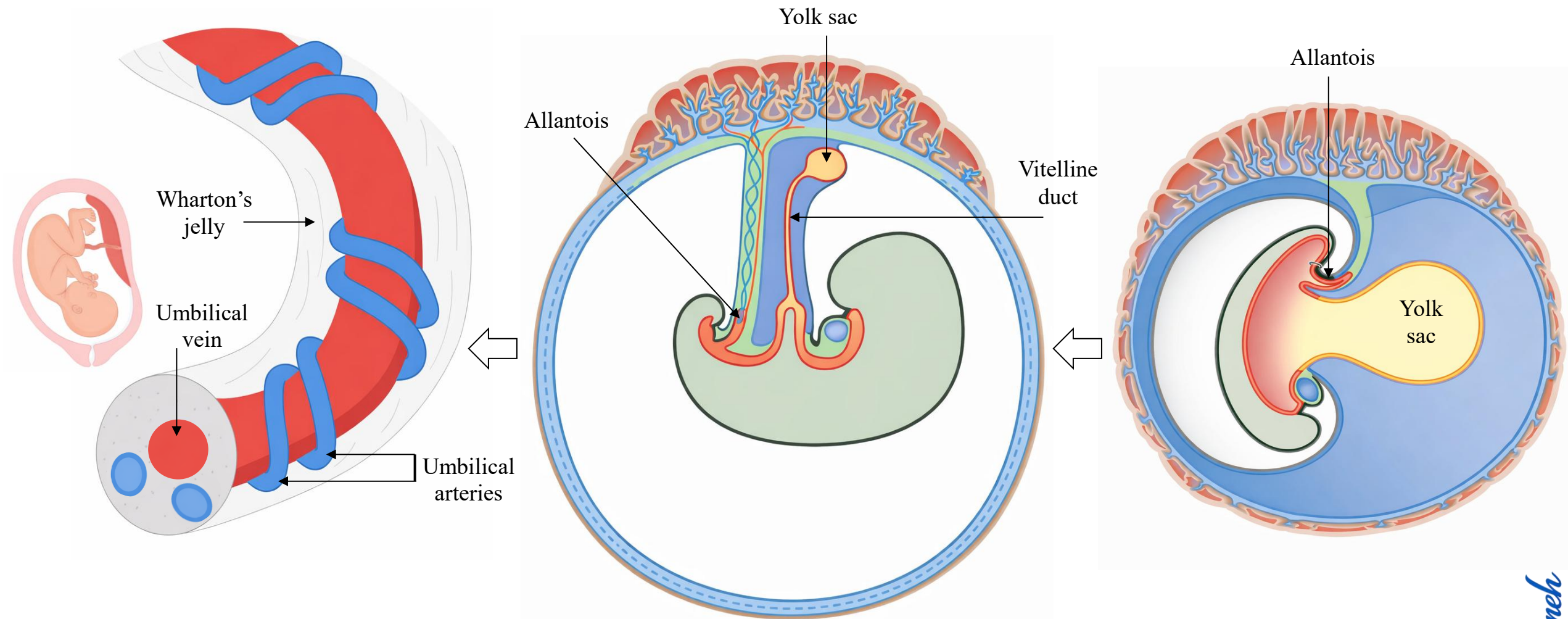
Wharton's
jelly



Changes leading to formation of the definitive umbilical cord:

- ✓ Return of the physiologically herniated intestinal loop to the abdominal cavity.
- ✓ Degeneration of the vitelline duct and allantois.
- ✓ Obliteration of the extraembryonic parts of the vitelline vessels.
- ✓ Obliteration of one umbilical vein, leaving two umbilical arteries and one umbilical vein.
- ✓ Transformation of the mesoderm of the connecting stalk into Wharton's jelly.





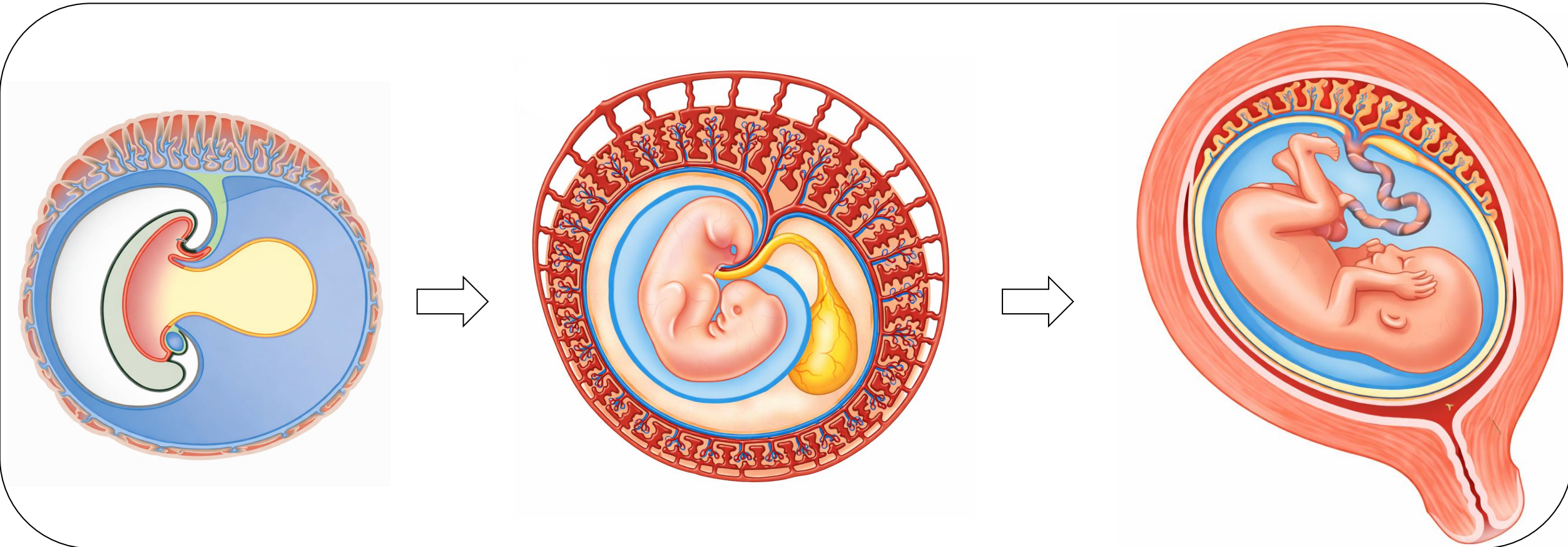
Definitive umbilical cord

Primitive umbilical cord

Primitive umbilical ring

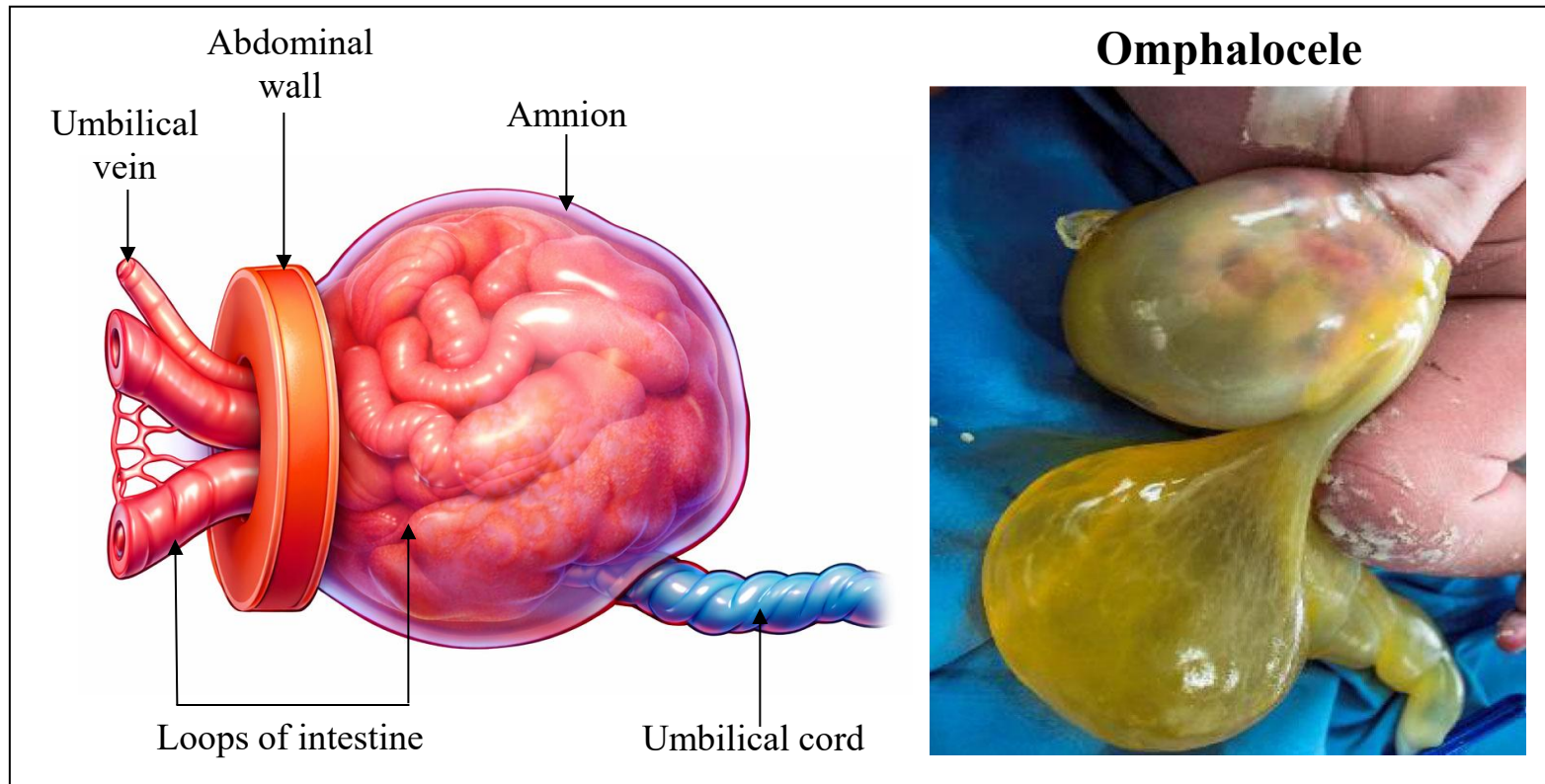
Note: The primitive umbilical cord contains several embryonic structures, while the definitive umbilical cord contains only the umbilical vessels embedded in Wharton's jelly.

Feature	Primitive Umbilical Ring	Primitive Umbilical Cord	Definitive Umbilical Cord
What is it?	An opening in the ventral body wall	Enclosed bundle of embryonic structures	Mature vascular cord
When?	Early week 4 (during folding)	Late week 4 → end of embryonic period (week 8)	Fetal life (after regression of temporary structures)
Nature	Anatomical opening	Transitional structure	Final functional structure
Covered by amnion?	No	Yes	Yes

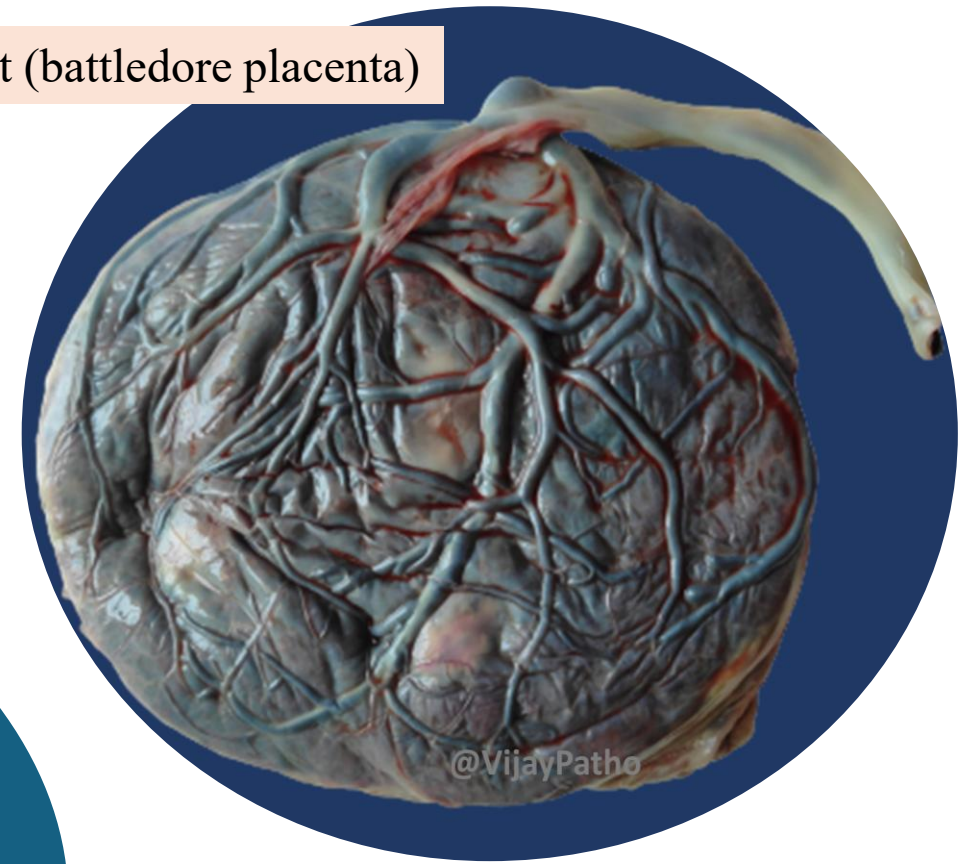


Abnormalities of the umbilical cord

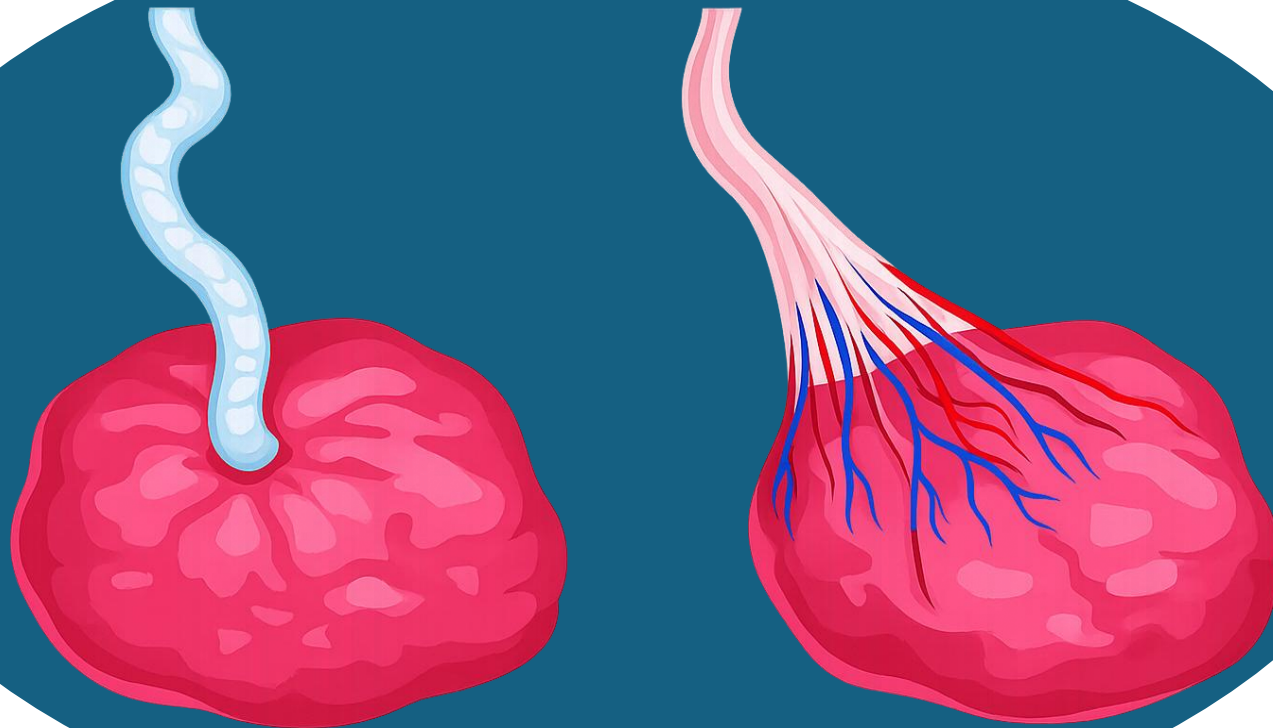
- ✓ **Short umbilical cord:** May lead to restricted fetal movements and can cause premature separation of the placenta.
- ✓ **Long umbilical cord:** May encircle the fetal neck and may form true knots.
- ✓ **Congenital umbilical hernia (omphalocele):** The umbilical cord contains coils of intestine due to failure of return of the intestinal loops to the abdominal cavity.
- ✓ **Single umbilical artery:** Presence of only one umbilical artery instead of two.
- ✓ **Abnormal attachment of the cord:**
 - Marginal attachment (battledore placenta)
 - Velamentous attachment: the cord inserts into the membranes, and vessels run within the membranes before reaching the placenta.



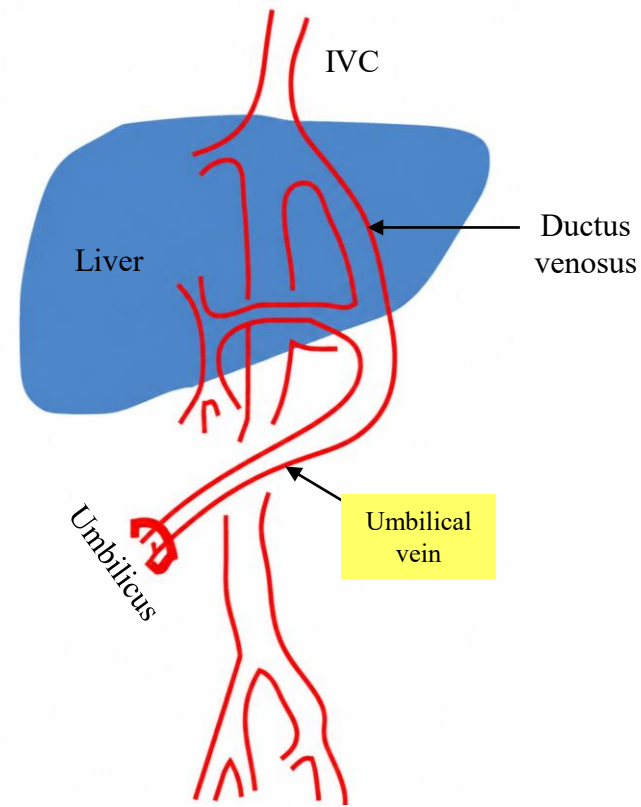
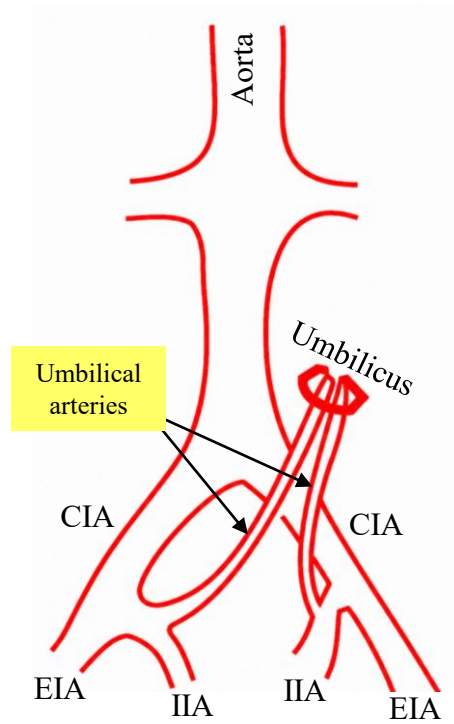
Marginal attachment (battledore placenta)



Velamentous attachment (velamentous placenta)



*Velamentous
means membranous*



Umbilical arteries

- Carry deoxygenated blood from the fetus to the placenta.
- Arise from the internal iliac arteries of the fetus.
- Pass upward on the internal surface of the anterior abdominal wall toward the umbilicus.
- Enter the umbilical cord through the umbilicus.
- Travel within the umbilical cord to the placenta.

Umbilical Vein

- Carries oxygenated blood from the placenta to the fetus.
- Enters the fetus through the umbilicus.
- Passes upward toward the liver (within the falciform ligament)
- Some blood goes through the liver.
- Most blood passes through the ductus venosus to the IVC.

Pathway of Fetal Circulation

1. Oxygenated Blood from Placenta

Oxygenated blood passes from the Placenta → through the Left umbilical vein

Read only 😊

2. Passage Through Liver

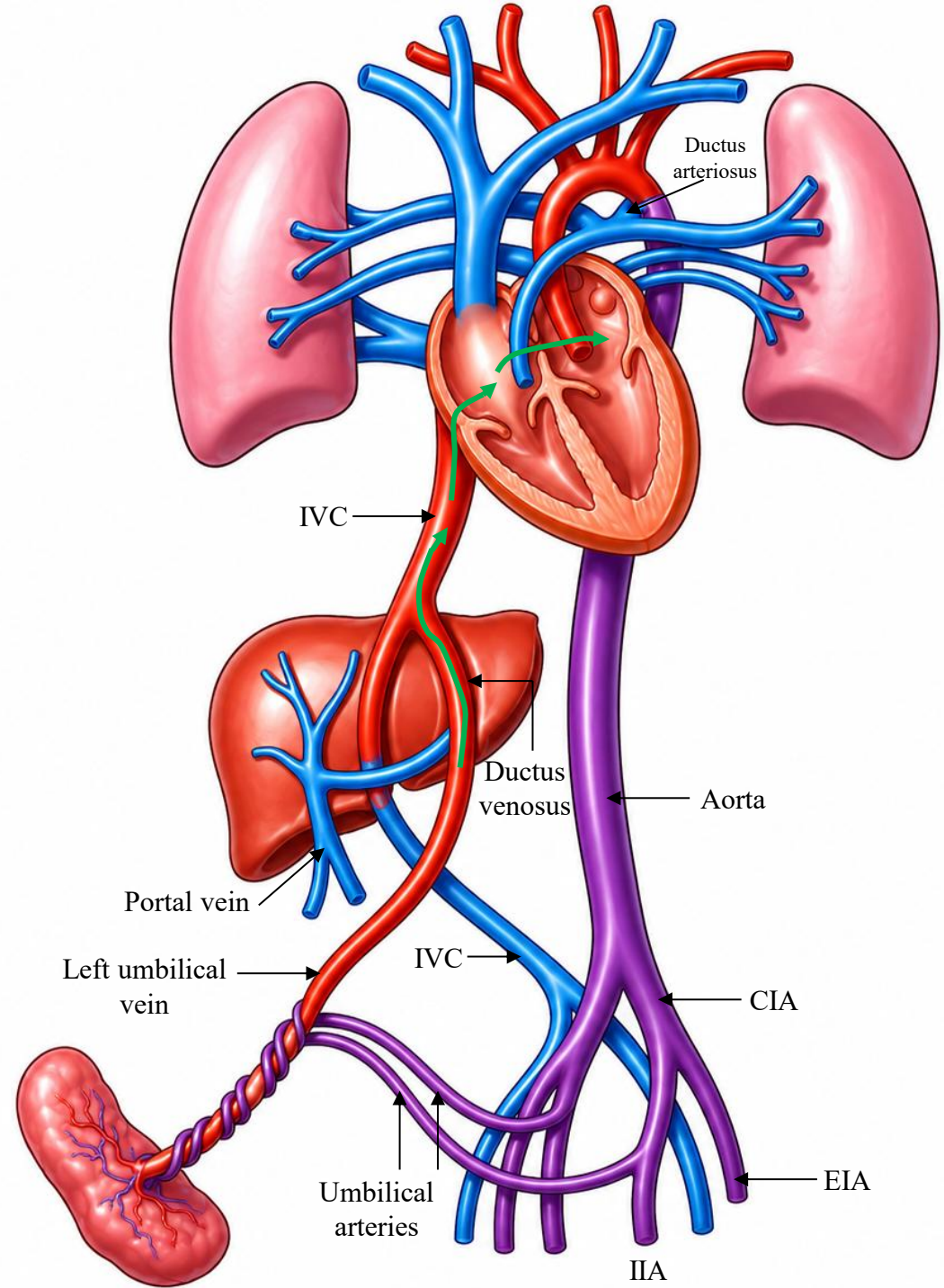
Most blood bypasses the liver through the Ductus venosus. Blood then enters the Inferior vena cava (IVC)

3. Right Atrium

Blood reaches the Right atrium. Most oxygenated blood is directed through the Foramen ovale → into the Left atrium

4. Left Side of Heart

Blood passes to Left atrium → Left ventricle → Ascending aorta. This highly oxygenated blood supplies: Heart, Head, Neck & Upper limbs



Prof. Dr. Heba Kalbouneh

5. Blood Returning from Head

Deoxygenated blood from the upper body returns through the Superior vena cava (SVC)

It enters Right atrium → Right ventricle → Pulmonary trunk

6. Ductus Arteriosus

Because fetal lungs are nonfunctional, only a small amount of blood goes to lungs.

Most blood passes through the Ductus arteriosus → into the Descending aorta

7. Return to Placenta

Blood in descending aorta passes to Internal iliac arteries → Umbilical arteries → Placenta

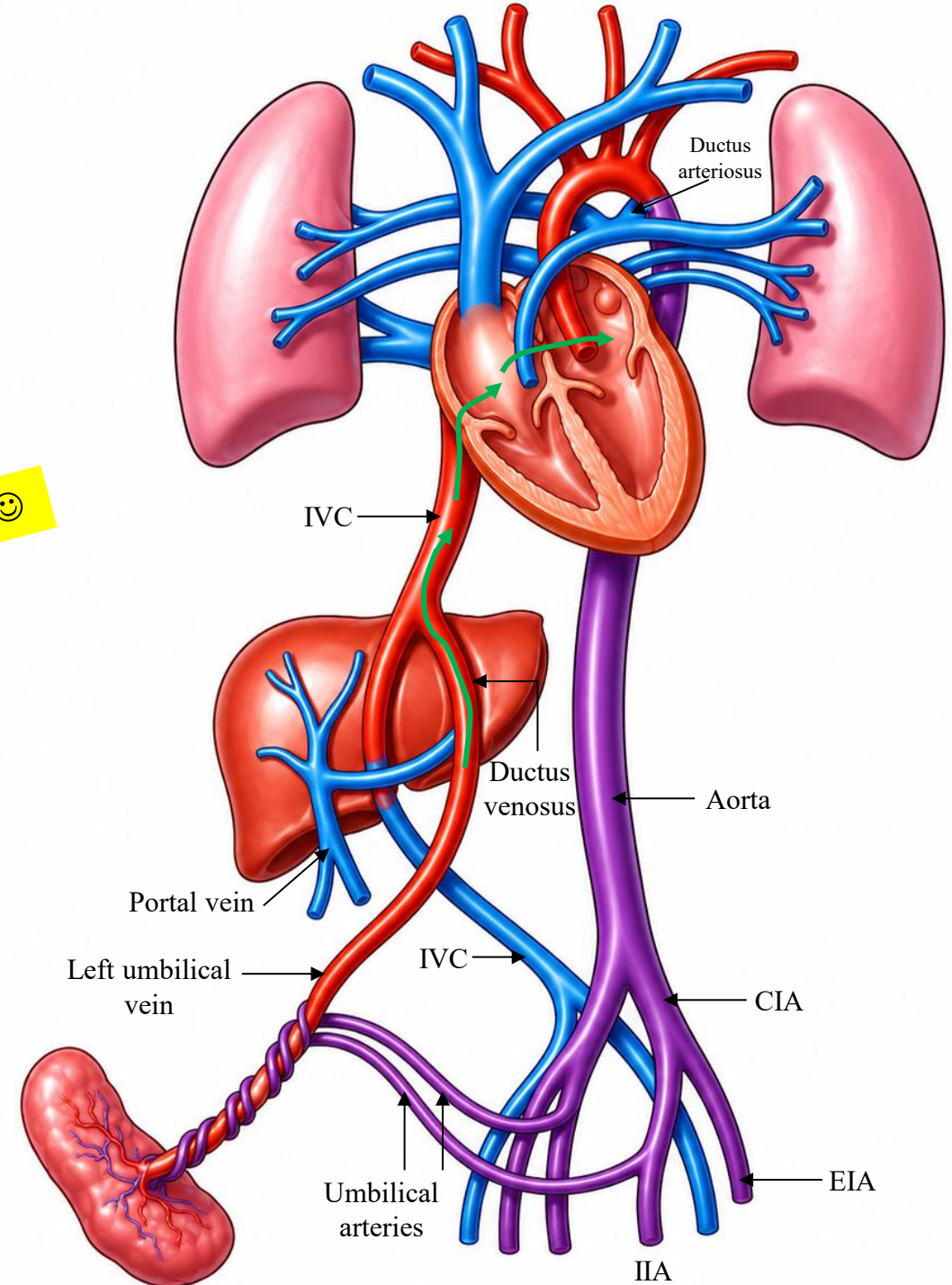
There, carbon dioxide and wastes are removed and blood becomes oxygenated again.

Placenta → Umbilical vein → Ductus venosus → IVC → Right atrium → Foramen ovale → Left atrium → Left ventricle → Aorta

Pulmonary Bypass Pathway

Right ventricle → Pulmonary trunk → Ductus arteriosus → Descending aorta

Read only 😊



Prof. Dr. Heba Kalbouneh

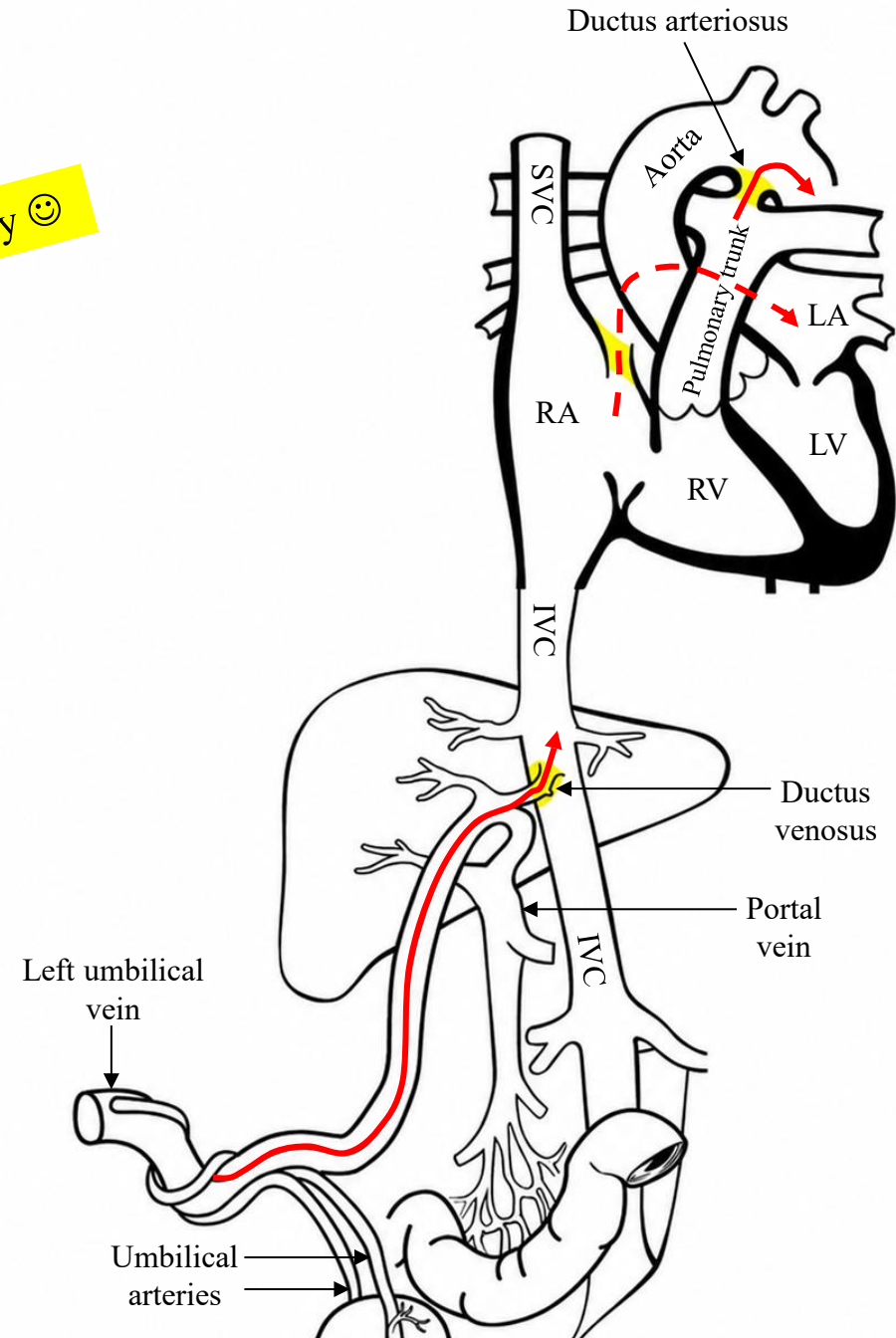
Fetal shunts

Shunt

Function

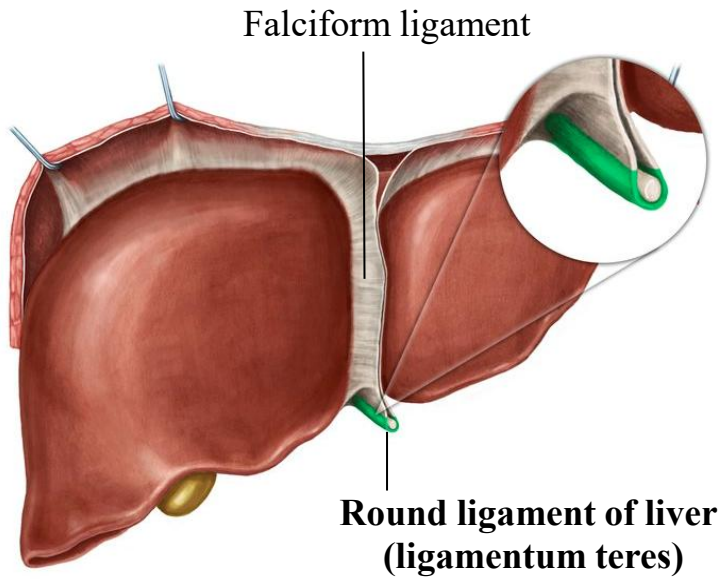
Ductus venosus	Bypasses liver
Foramen ovale	Shunts blood from right atrium to left atrium
Ductus arteriosus	Shunts blood from pulmonary trunk to aorta

Read only 😊

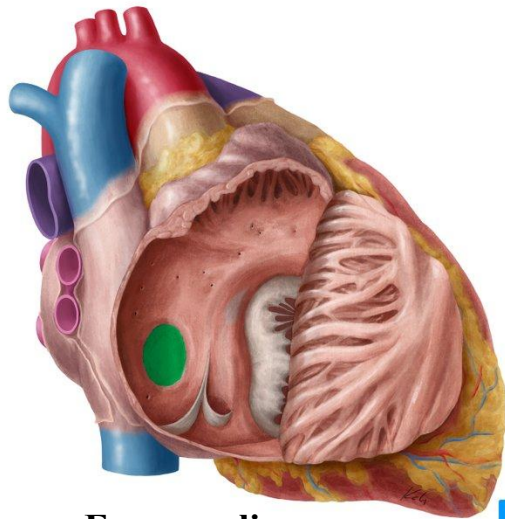


Important Features of Fetal Circulation

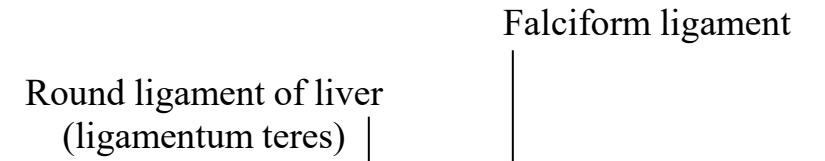
- Placenta replaces lung function.
- Right and left sides of heart work in parallel.
- Pulmonary circulation is minimal.
- Most oxygenated blood reaches the brain and heart first.



© www.kenhub.com



© www.kenhub.com



Peritoneum

Medial umbilical fold

Urinary bladder

Read only 😊

Fetal structure

Ductus arteriosus

Foramen ovale

Ductus venosus

Umbilical vein

Umbilical arteries

Adult remnant

Ligamentum arteriosum

Fossa ovalis

Ligamentum venosum

Ligamentum teres

Medial umbilical ligaments

Prof. Dr.
Heba Kalbouneh

Fate of connecting stalk:

- ✓ Its mesenchymal tissue differentiates into **Wharton's jelly** of the definitive umbilical cord, within which the umbilical vessels are embedded.

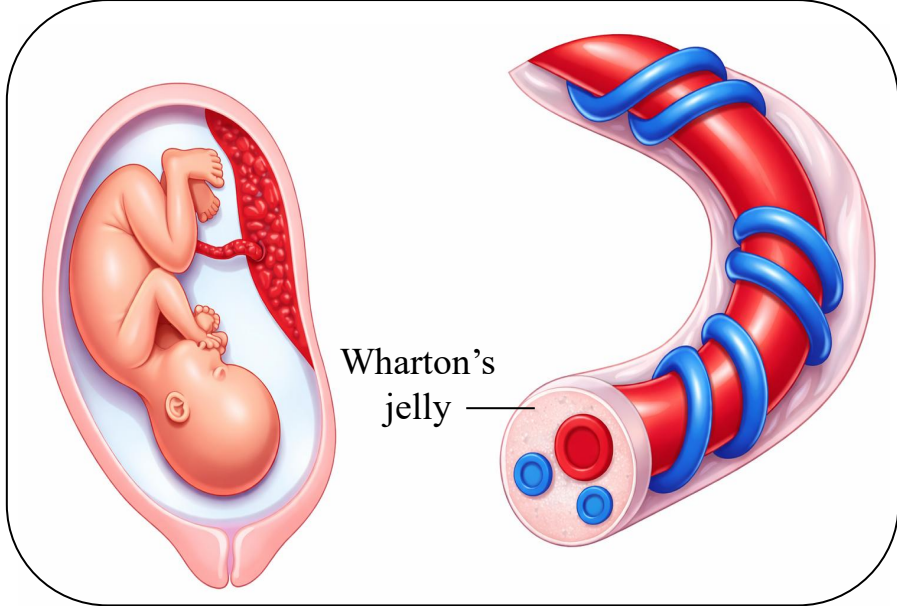
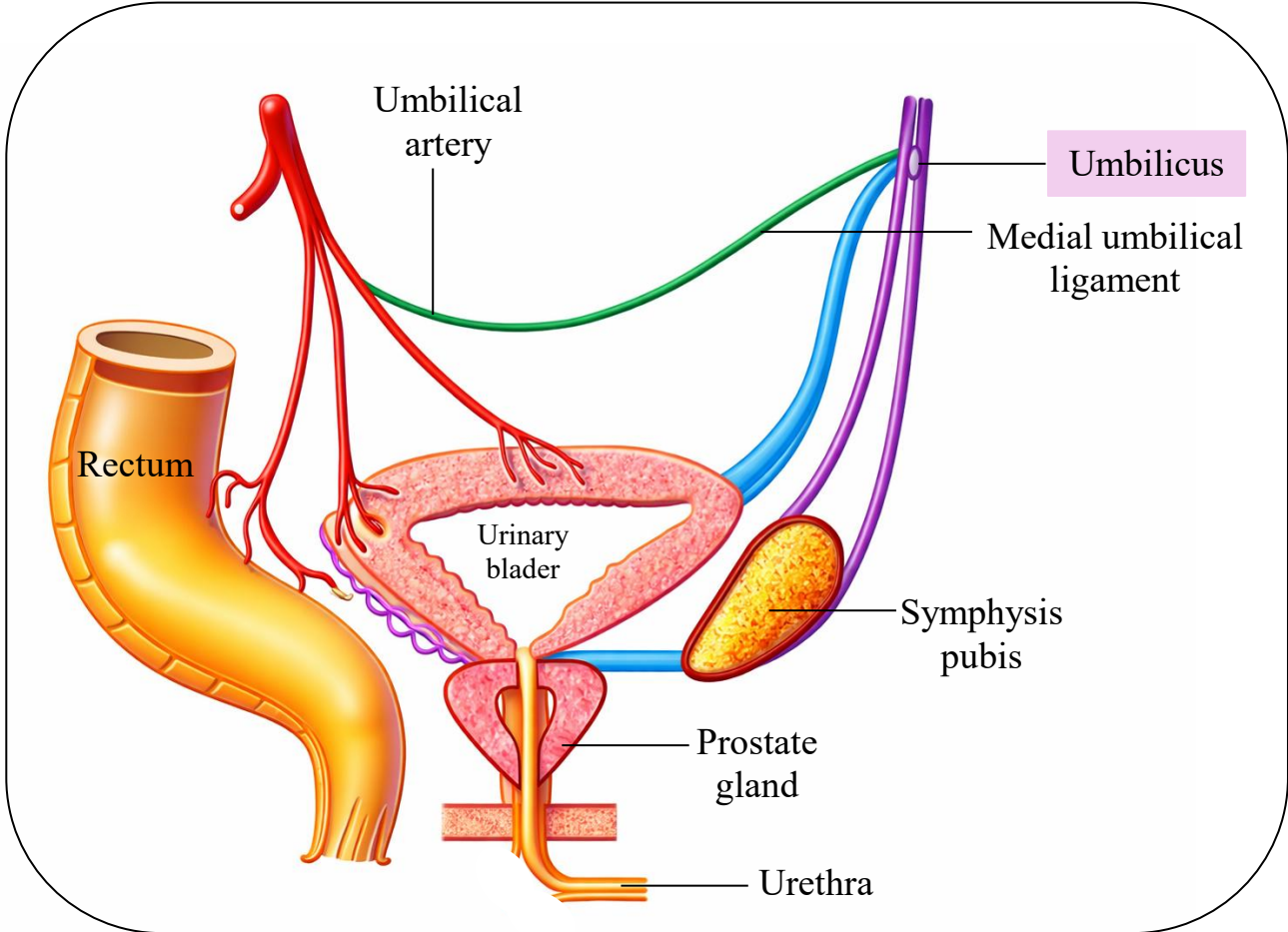
After birth:

- ✓ The umbilical arteries become the **medial umbilical ligaments**
- ✓ The umbilical vein becomes the **ligamentum teres of the liver**

Read only 😊

Remember: the connecting stalk is composed of extraembryonic mesoderm.

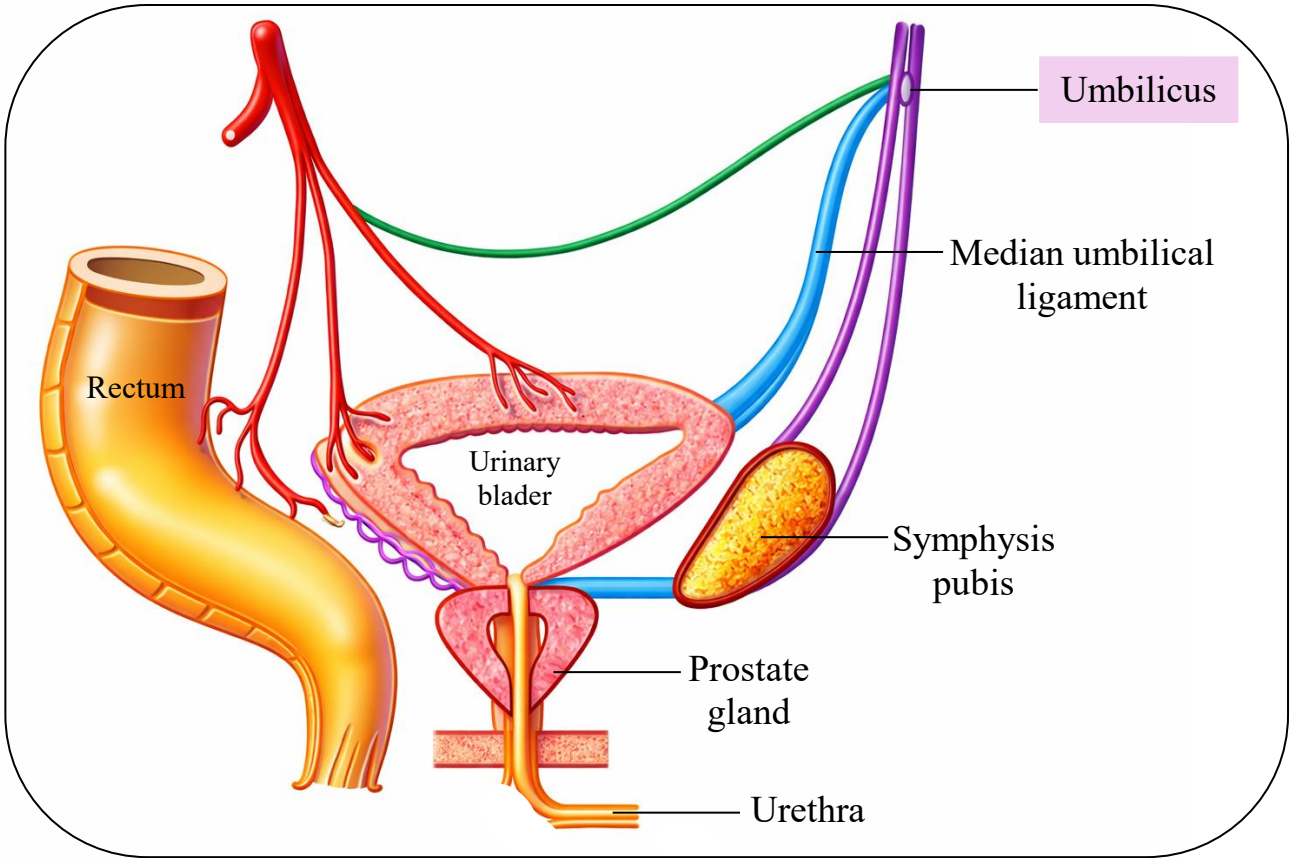
Prof. Dr. Heba Kalbouneh



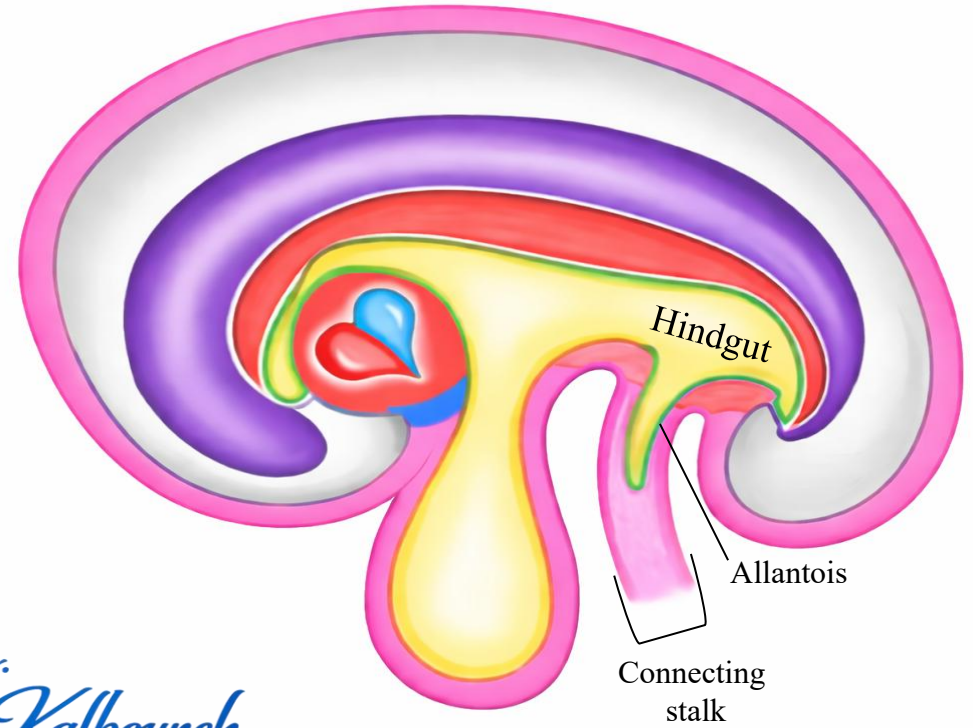
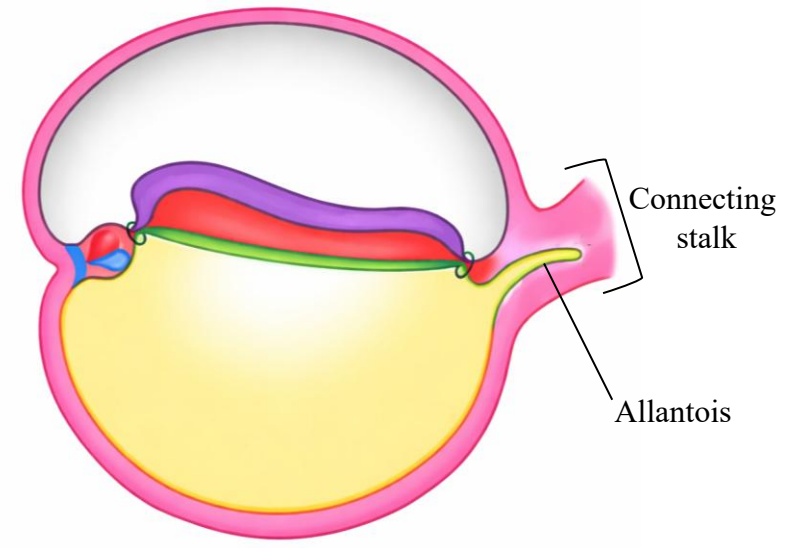
During fetal life → umbilical vessels are functional
After birth → they close and become fibrous ligaments

Fate of allantois

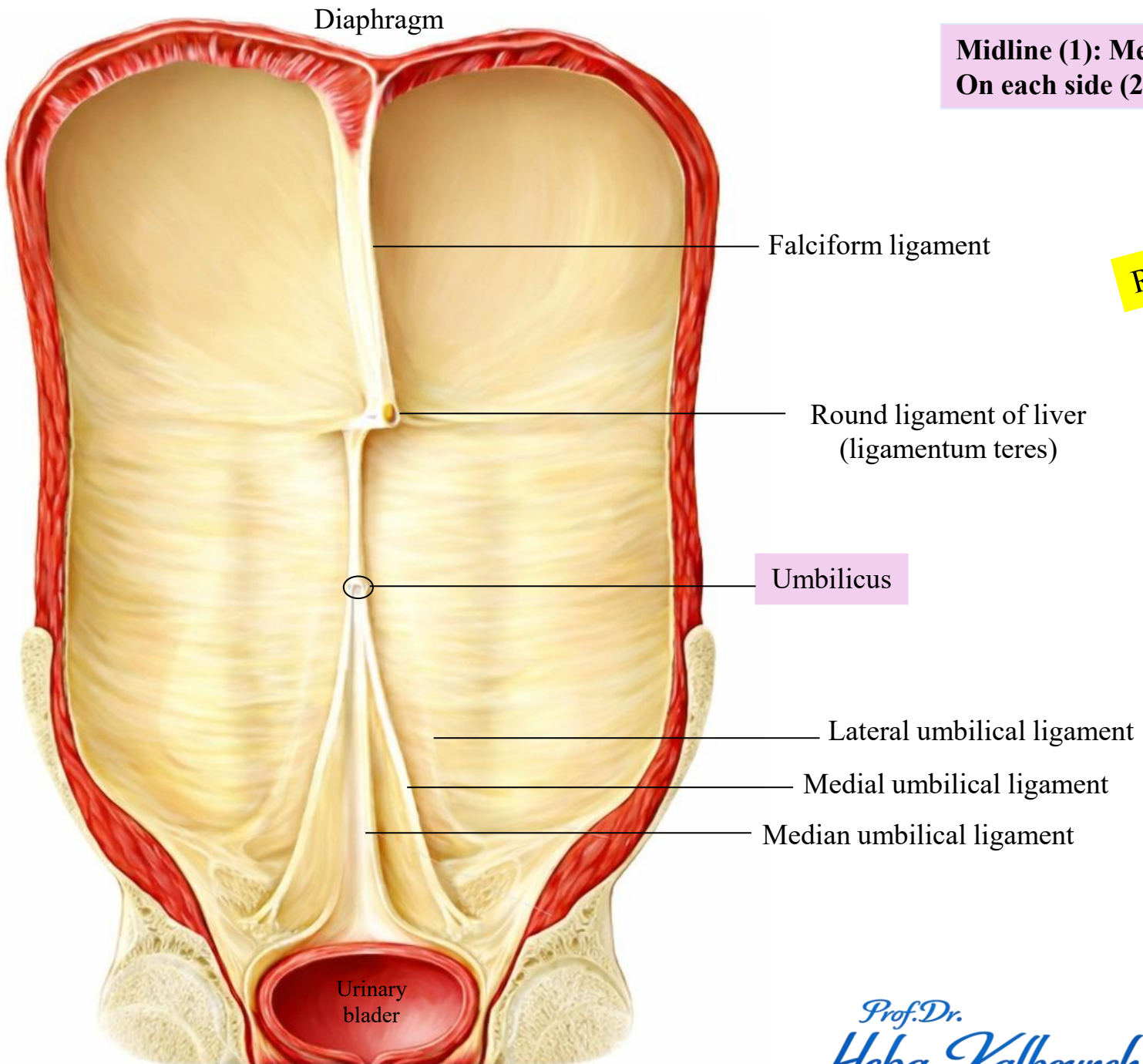
- ✓ The allantois appears early as an endodermal tube-like outgrowth extending from the yolk sac (hindgut region) into the connecting stalk.
- ✓ During the embryonic period, its intraembryonic portion becomes a fibrous cord known as the **urachus**, connecting the apex of the bladder to the umbilicus.
- ✓ After birth, the urachus forms the **median umbilical ligament**.



Read only 😊

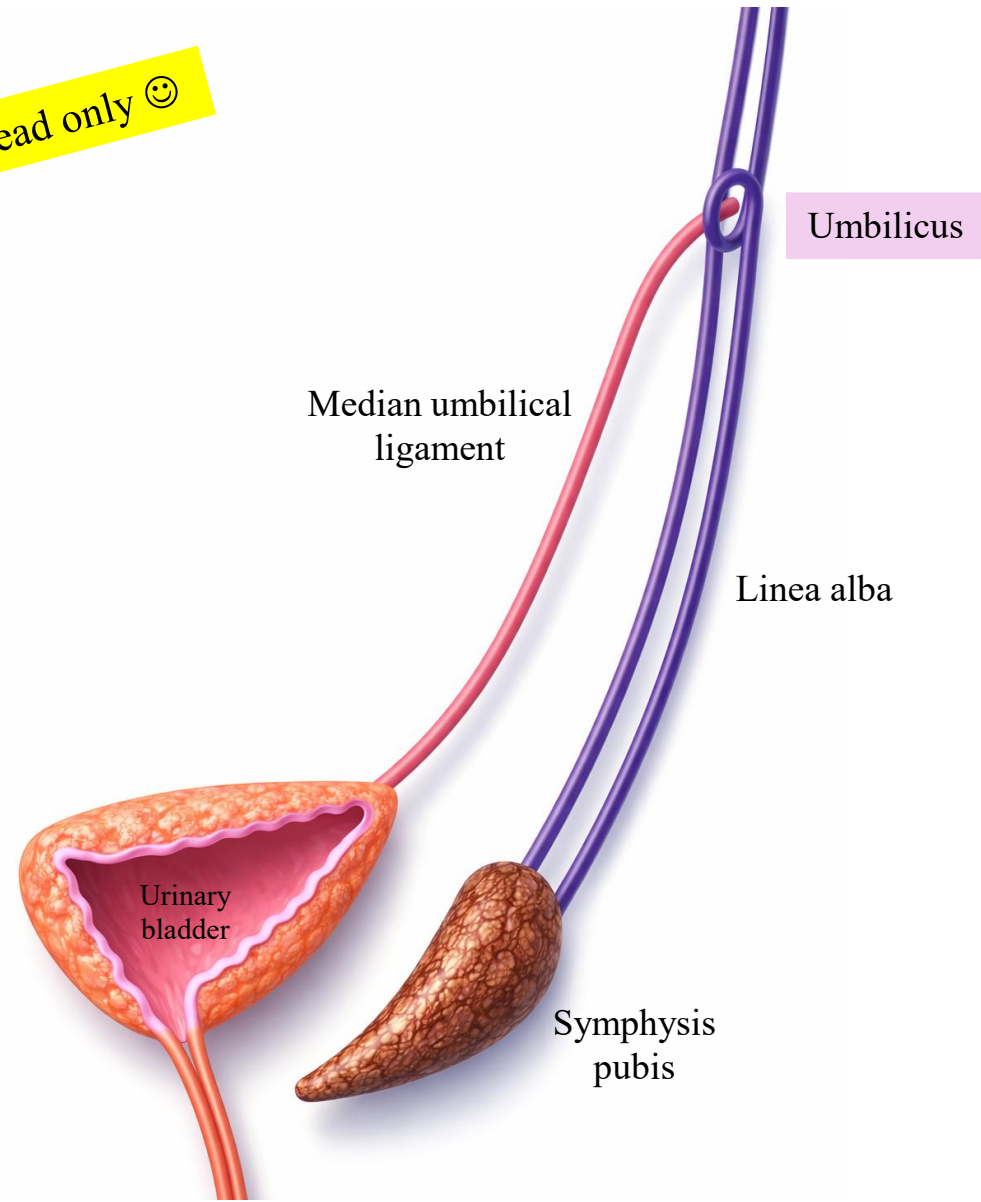


Prof. Dr.
Heba Kalbouneh



Midline (1): Median umbilical ligament → urachus (allantois)
On each side (2): Medial umbilical ligaments → obliterated umbilical arteries

Read only 😊



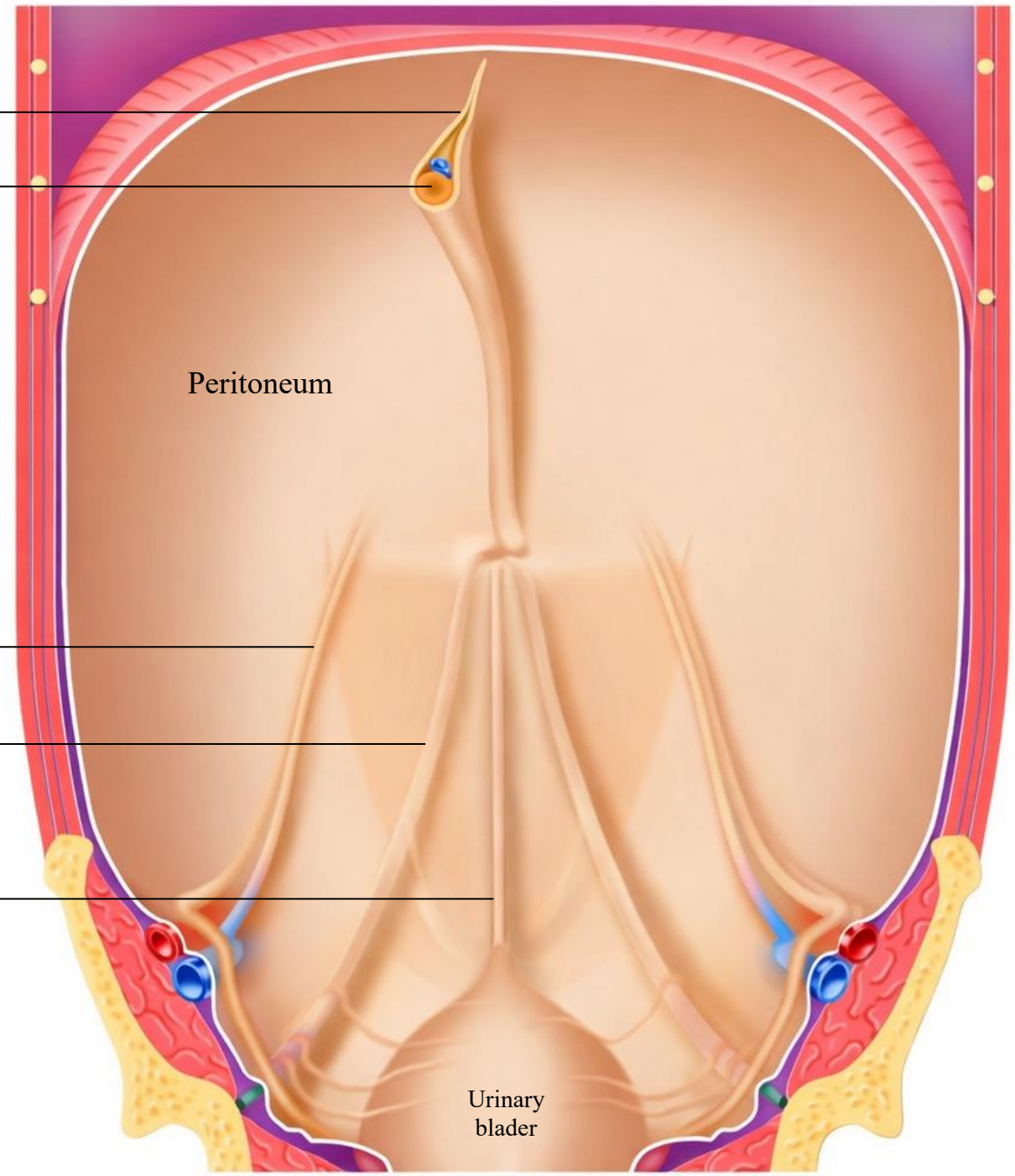
Prof. Dr.
Heba Kalbouneh

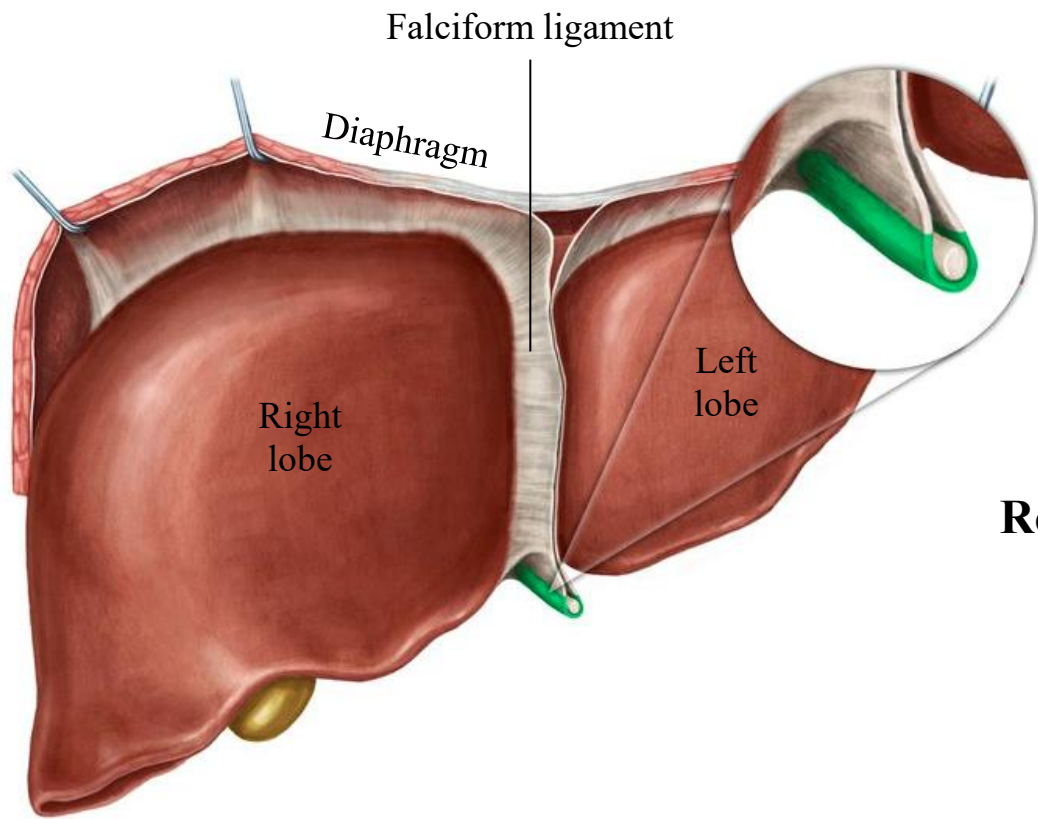
The **umbilical ligaments** are fibrous remnants of fetal blood vessels found on the inner surface of the anterior abdominal wall after birth.

Read only 😊

Falciform ligament
Round ligament of liver
(ligamentum teres)

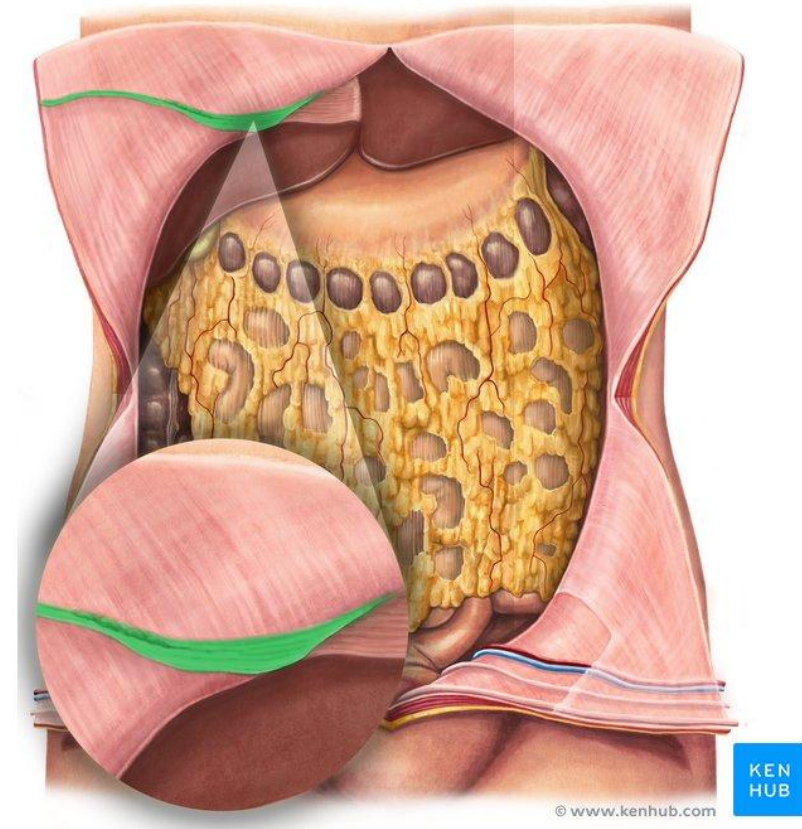
Lateral umbilical fold
Medial umbilical fold
(overlying the medial umbilical ligament, which is the obliterated fetal umbilical artery)
Median umbilical fold
(overlying the median umbilical ligament, which is a remnant of the fetal urachus)





Read only 😊

Round ligament of liver (ligamentum teres)



© www.kenhub.com

KEN HUB

The **falciform ligament** is a thin fold of peritoneum that attaches the liver to the anterior abdominal wall and the diaphragm.
 → It helps hold the liver in position and divides the liver into right and left lobes on its anterior surface.
 → Its free lower border contains the **round ligament of the liver (ligamentum teres)**, which is the remnant of the fetal umbilical vein.

Prof. Dr.
Heba Kalbouneh

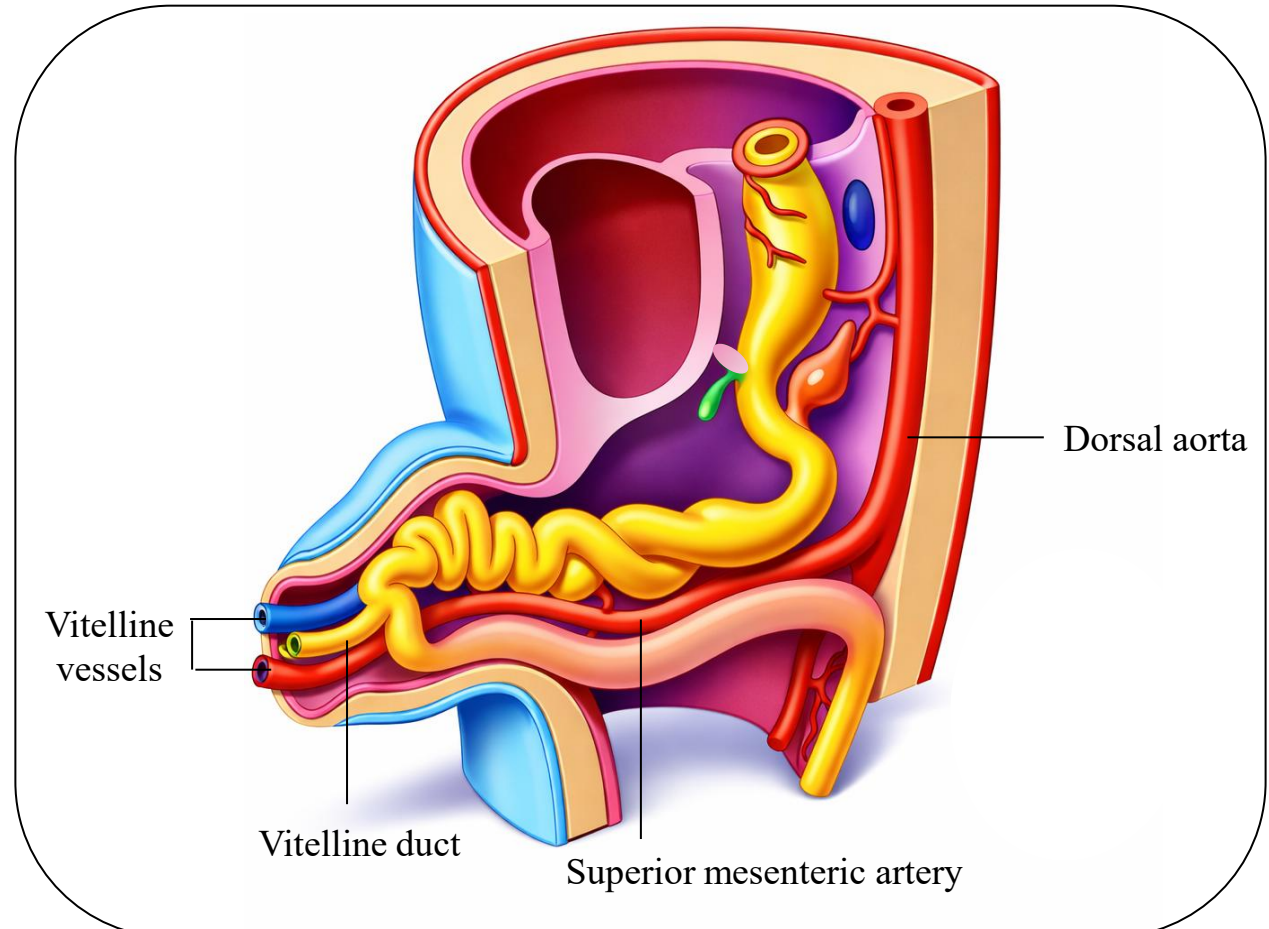
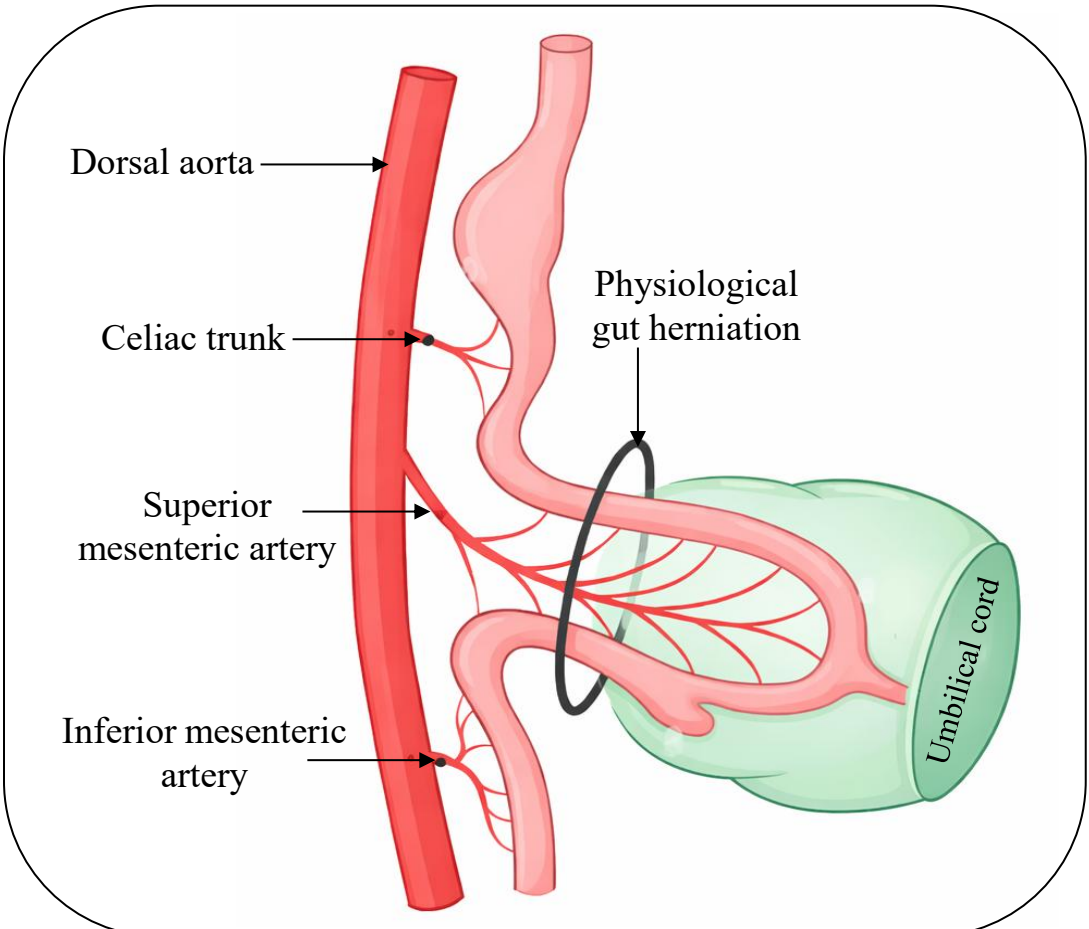
Read only 😊

Fate of the Vitelline Duct

- The vitelline duct is a narrow tubular connection between the midgut and the yolk sac.
- It is accompanied by the vitelline vessels.

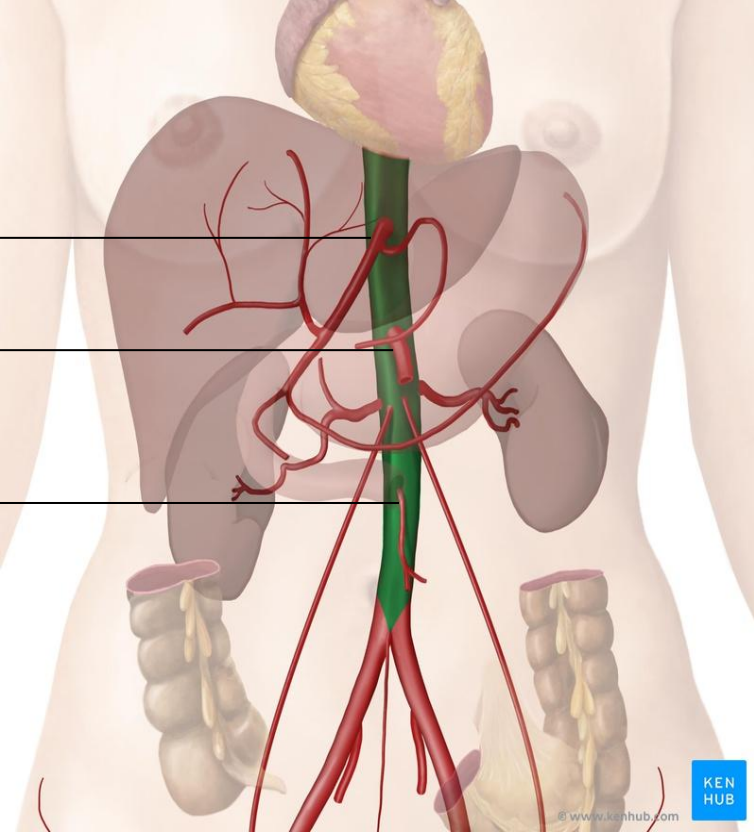
Normally:

- ✓ The vitelline duct undergoes complete obliteration (By the end of the 7th week).
- ✓ The vitelline arteries contribute to formation of the **superior mesenteric artery**, the main artery of the midgut.
- ✓ The vitelline veins contribute to formation of the **portal venous system**.

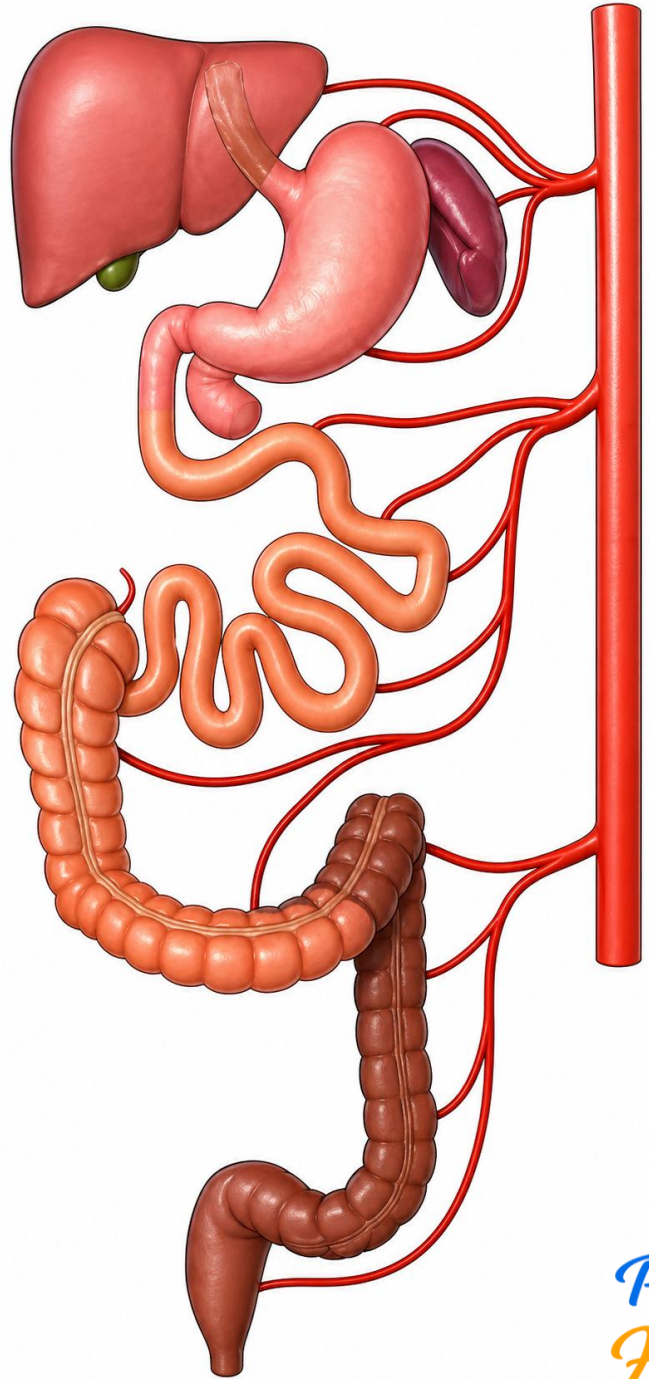


Read only 😊

Celiac trunk
Superior mesenteric artery
Inferior mesenteric artery

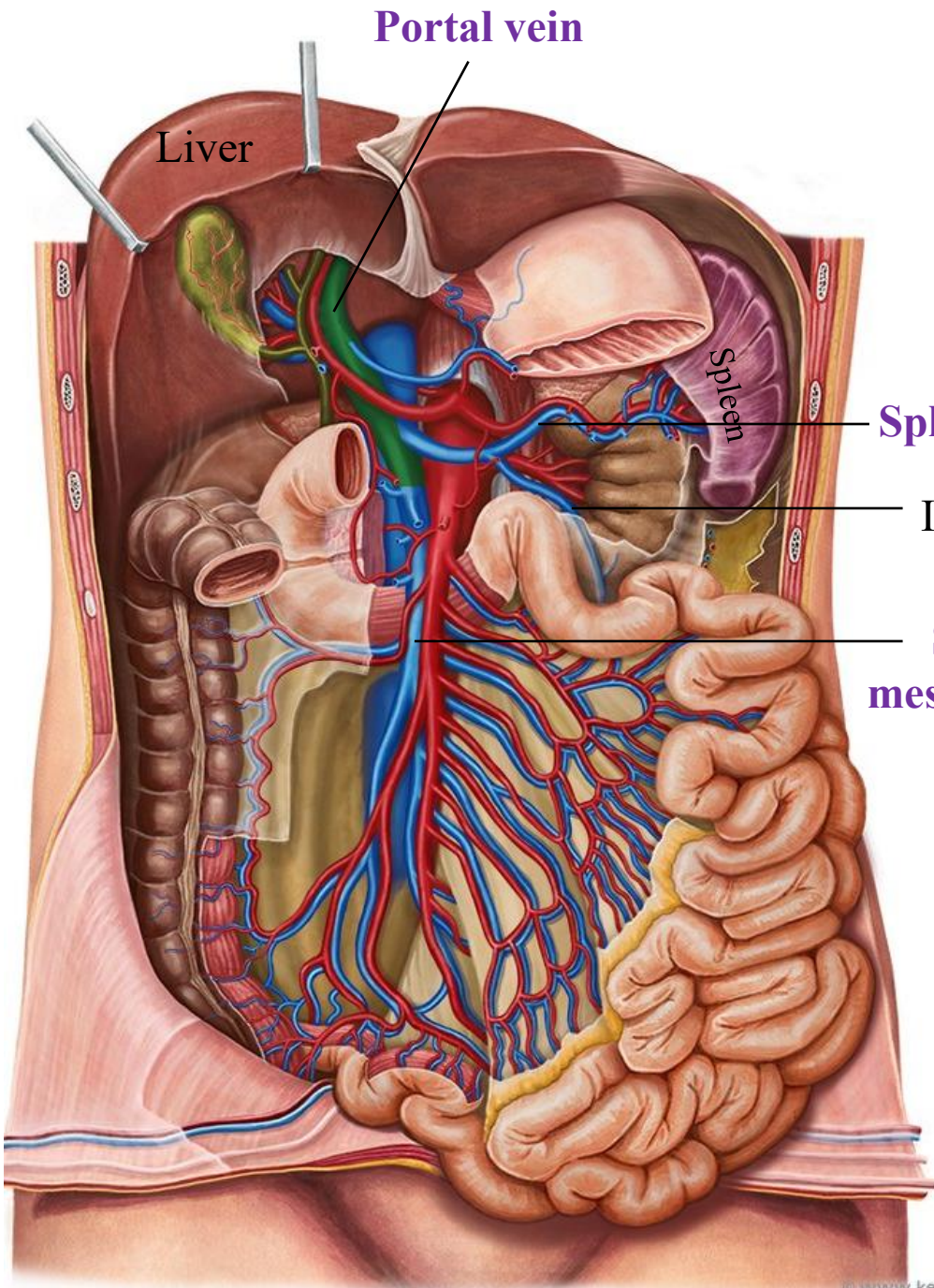


Foregut
Midgut
Hindgut



Celiac trunk
Superior mesenteric artery
Inferior mesenteric artery

Prof. Dr.
Heba Kalbouneh



Portal vein

Liver

Spleen

Splenic vein

Inferior mesenteric vein

Superior mesenteric vein

Read only 😊

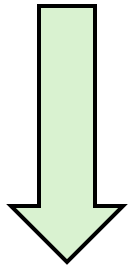
The **portal venous system** is a system of veins that carries blood from the digestive organs and spleen to the liver before the blood returns to the heart.
→ It transports nutrient-rich blood from organs such as the stomach, intestines, pancreas, and spleen to the liver for processing, storage, and detoxification.

The portal vein is formed by splenic vein and superior mesenteric vein

Inferior mesenteric vein drains into splenic vein

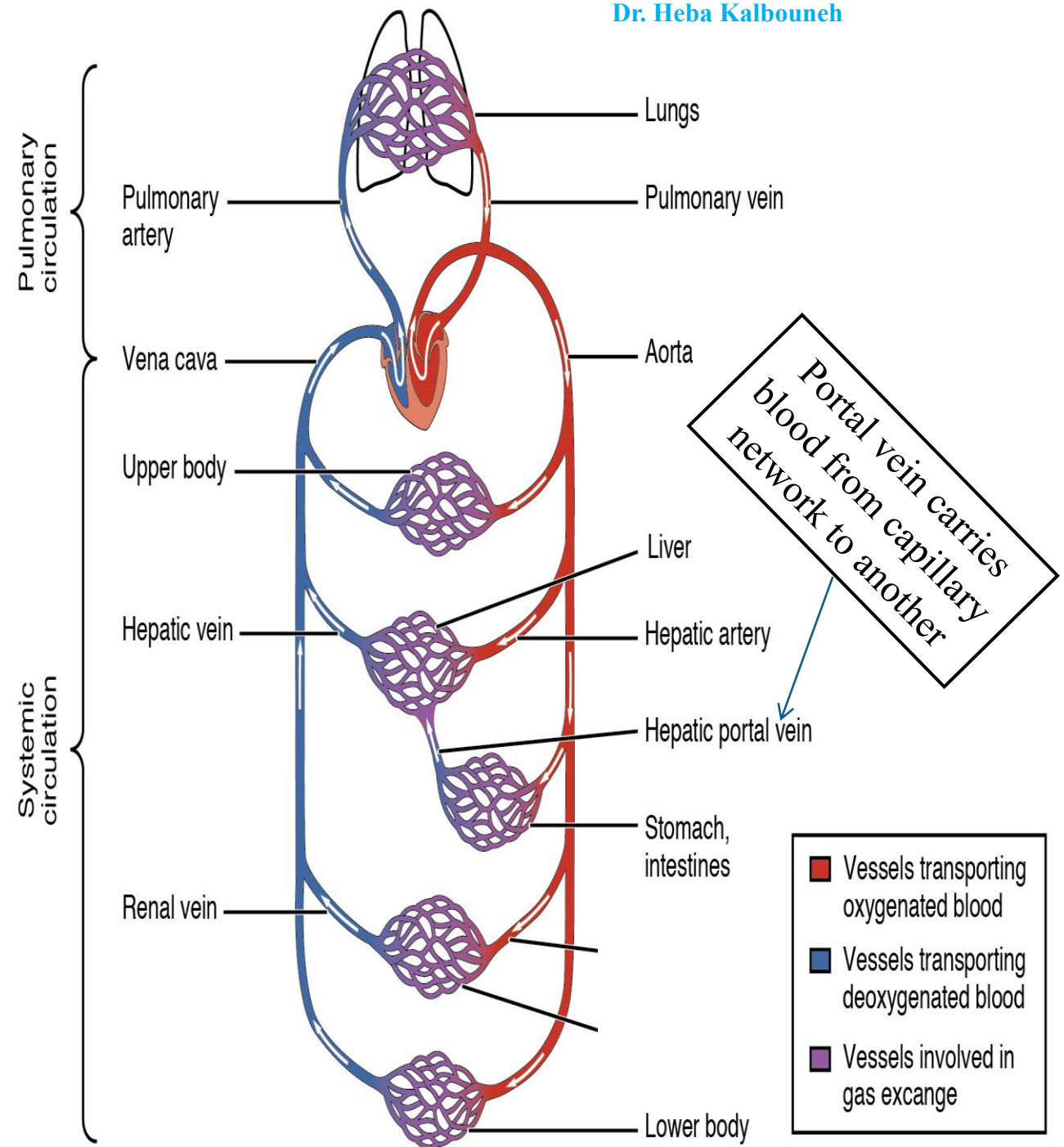
Portal circulation

The **portal venous system** is responsible for directing blood from parts of the gastrointestinal tract (from the lower third of the esophagus to halfway down the anal canal), spleen and pancreas to the liver. Substances absorbed in the small intestine travel first to the liver for processing before continuing to the heart.

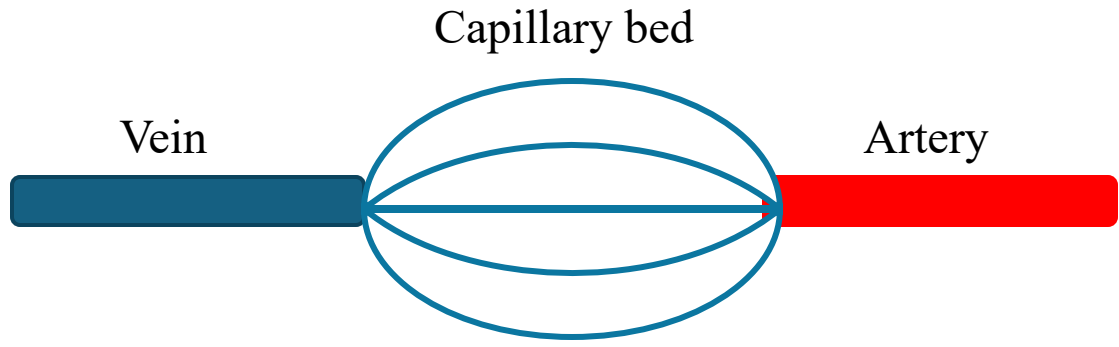


Read only 😊

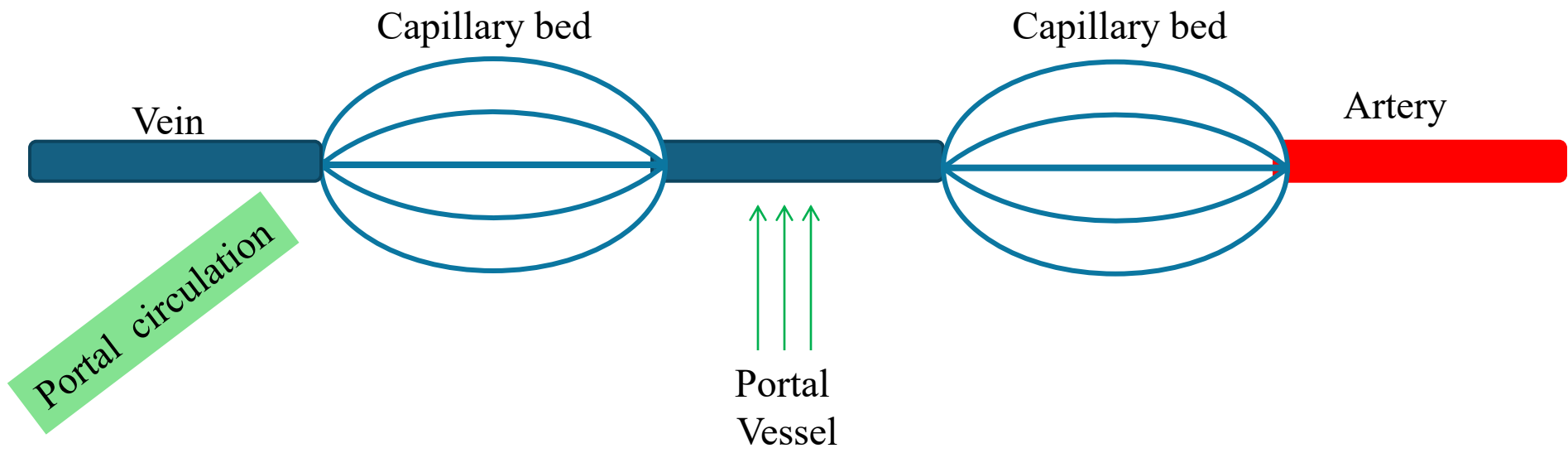
Therefore the portal vein is a blood vessel that sends nutrient-rich blood (but poor in oxygen) from the gastrointestinal tract, pancreas and spleen to the liver.



Systemic circulation



Read only 😊



Portal circulation

Portal vein in liver
Efferent arteriole in kidney

Portal venous system