Lecture (50 and 51)
The embryonic period

By

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Learning objectives

1- Know the derivatives of mesoderm.

2- Know the derivatives of endoderm.

3- Know the external appearance of embryo during second month.

Differentiation of the mesodermal germ layer

1- The cells of the mesodermal germ layer form a thin sheet of loosely arranged tissue on each side of midline.

2-At 17th day of development, cells close to the midline proliferate and form thickened plate of tissue called **paraxial mesoderm**.

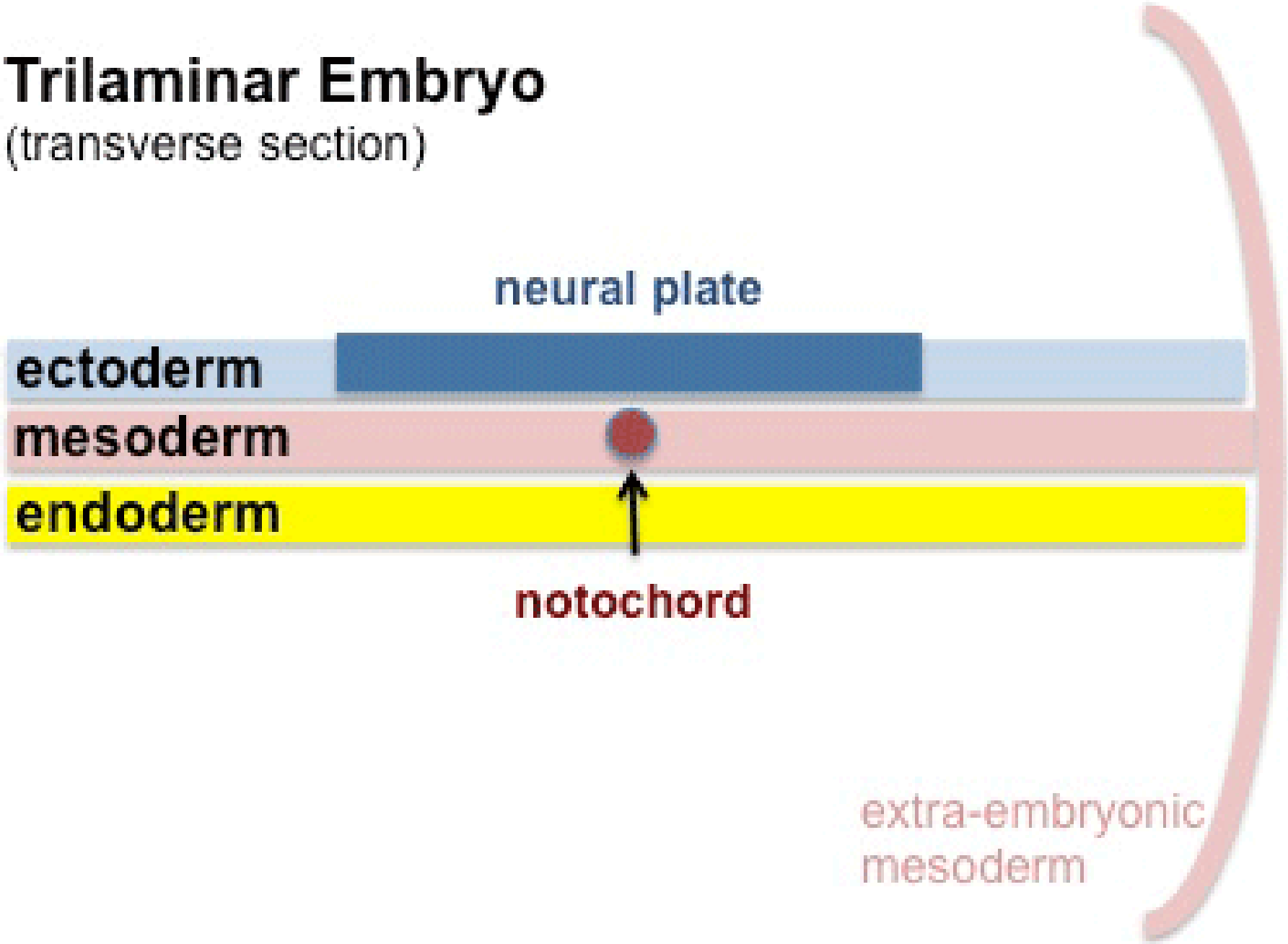
3- laterally, the mesoderm remains thin and called **lateral mesoderm.**

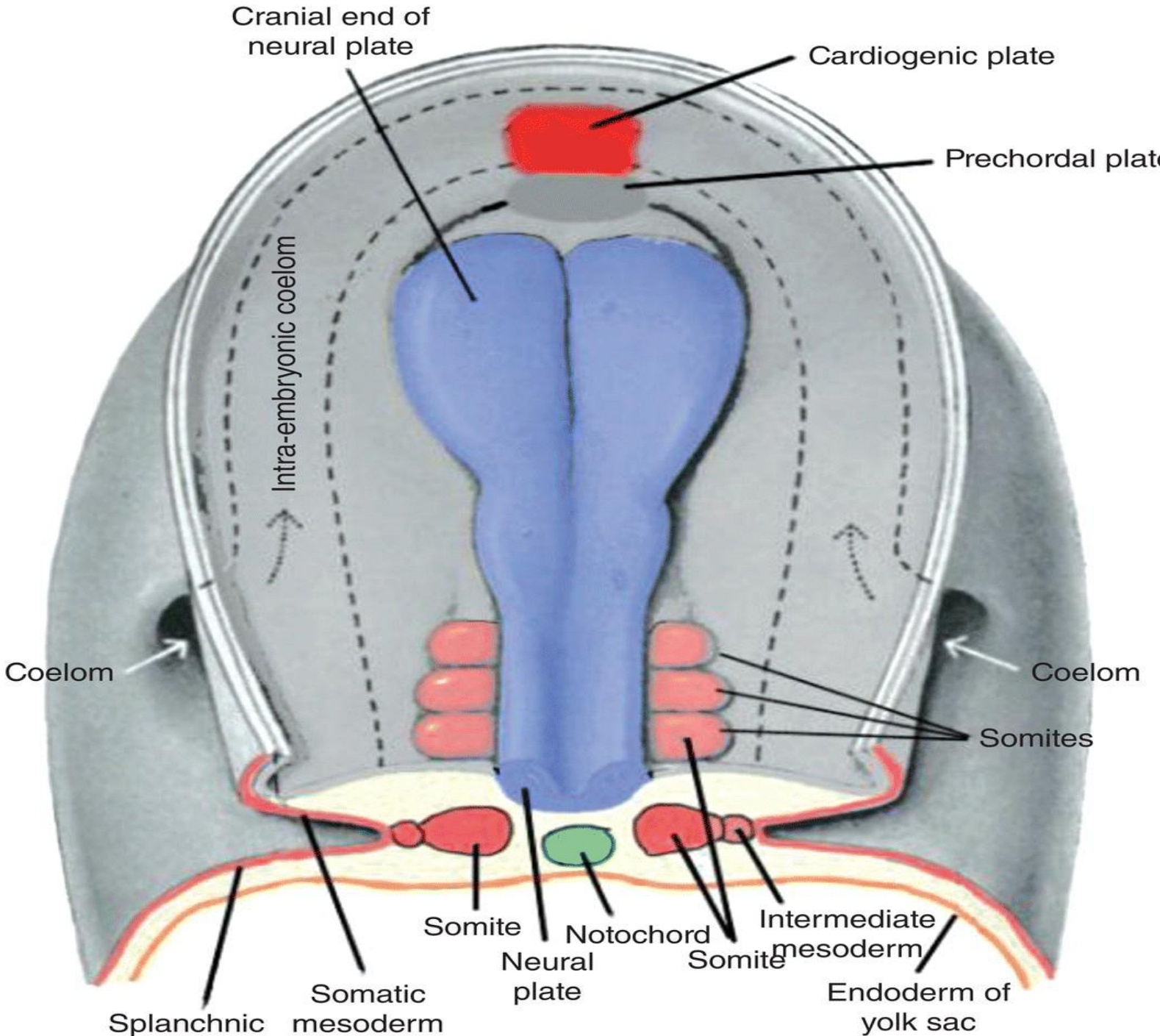
4- The appearance of intraembryonic coelom in the lateral mesoderm, divides into 2 layers :

(a) **Somatic or parietal mesodermal layer** which is continuous with mesoderm covering the amnion.

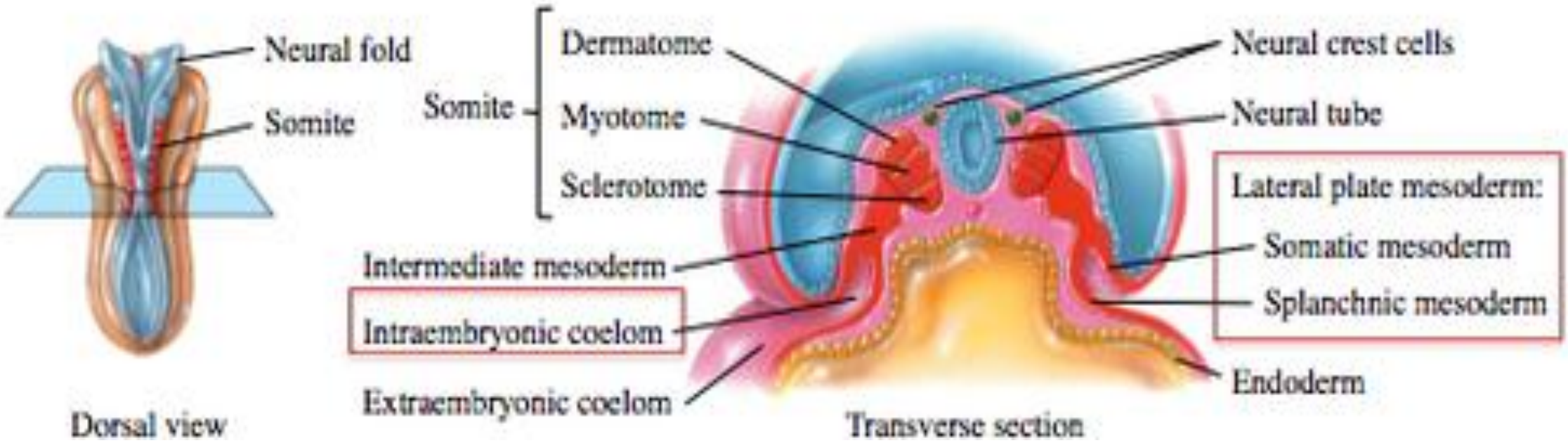
Trilaminar Embryo

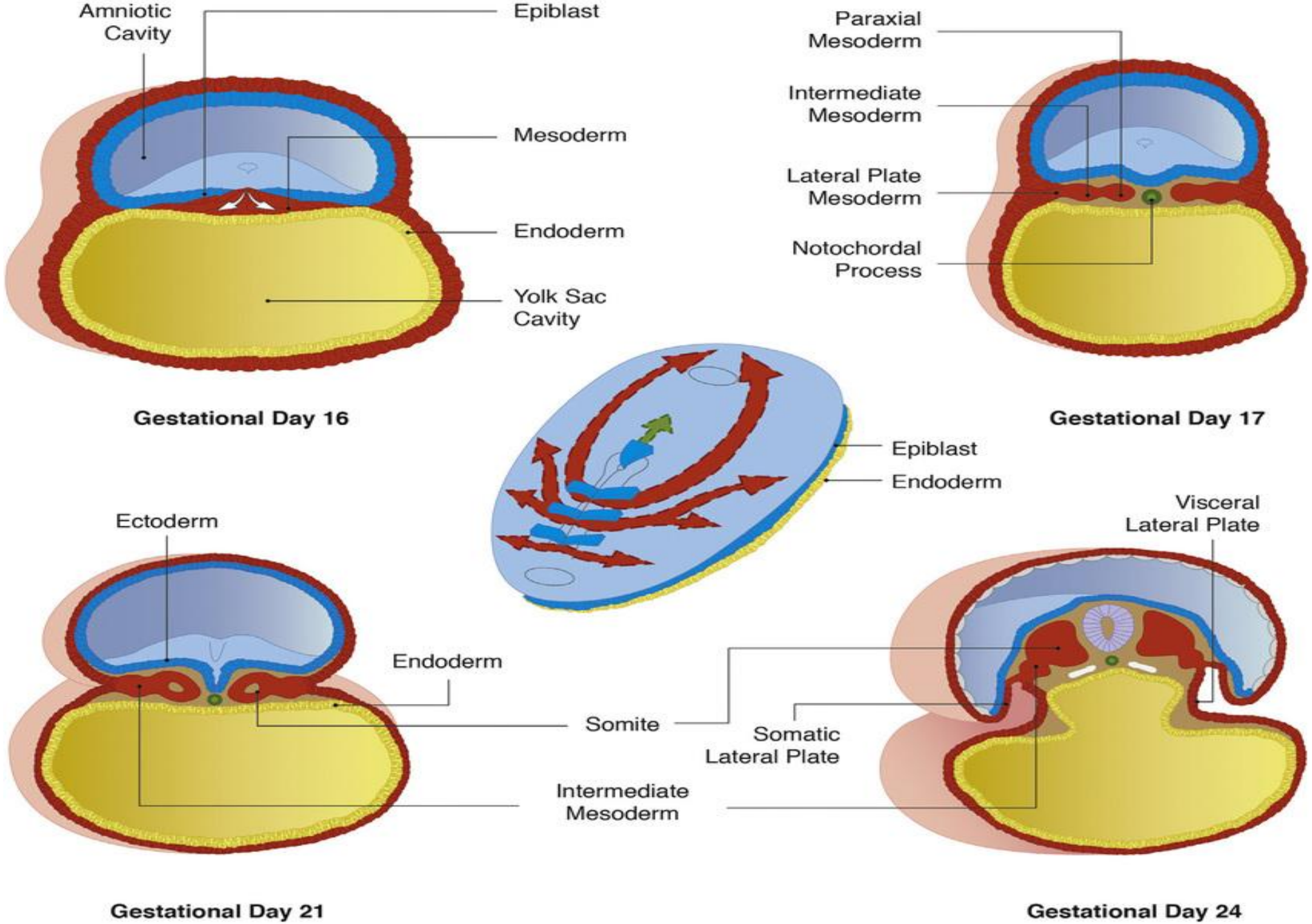
(transverse section)




Cranial end of neural plate
Cardiogenic plate
Prechordal plate
Intra-embryonic coelom
Coelom
Coelom
Somites
Somite
Notochord
Neural plate
Somite
Intermediate mesoderm
Splanchnic
Somatic mesoderm
Endoderm of yolk sac

Intraembryonic coelom




Amniotic Cavity
Epiblast
Mesoderm
Endoderm
Yolk Sac Cavity
Gestational Day 16
Paraxial Mesoderm
Intermediate Mesoderm
Lateral Plate Mesoderm
Notochordal Process
Gestational Day 17
Epiblast
Endoderm
Ectoderm
Endoderm
Somite
Intermediate Mesoderm
Gestational Day 21
Visceral Lateral Plate
Somatic Lateral Plate
Gestational Day 24

(b)**Visceral or splanchnic mesodermal layer which is** continuous with mesoderm covering the yolk sac. Both layers of lateral mesoderm line a new cavity called **intraembryonic cavity.**

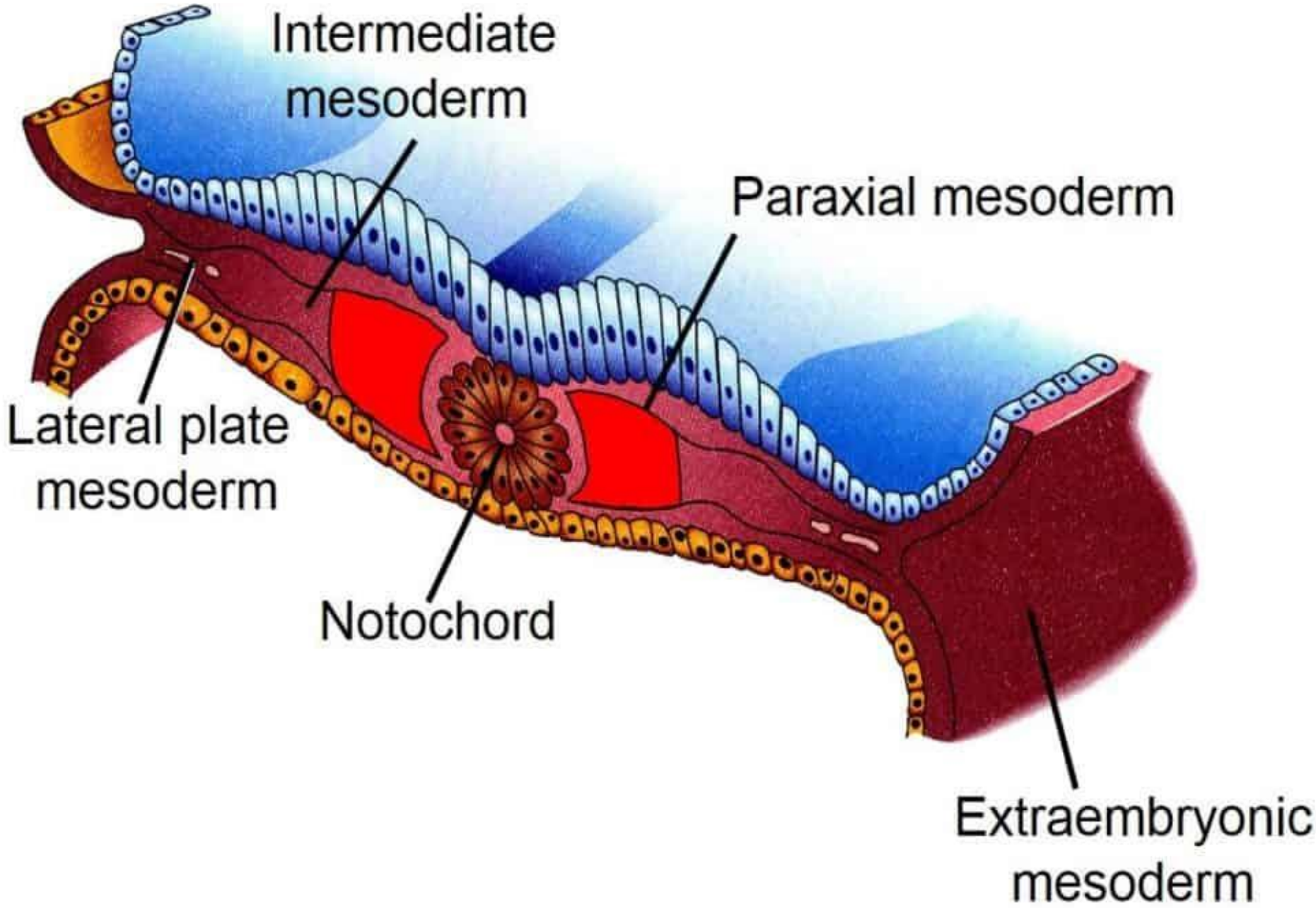
5- **Intermediate mesoderm connects** paraxial and lateral plate mesoderm.

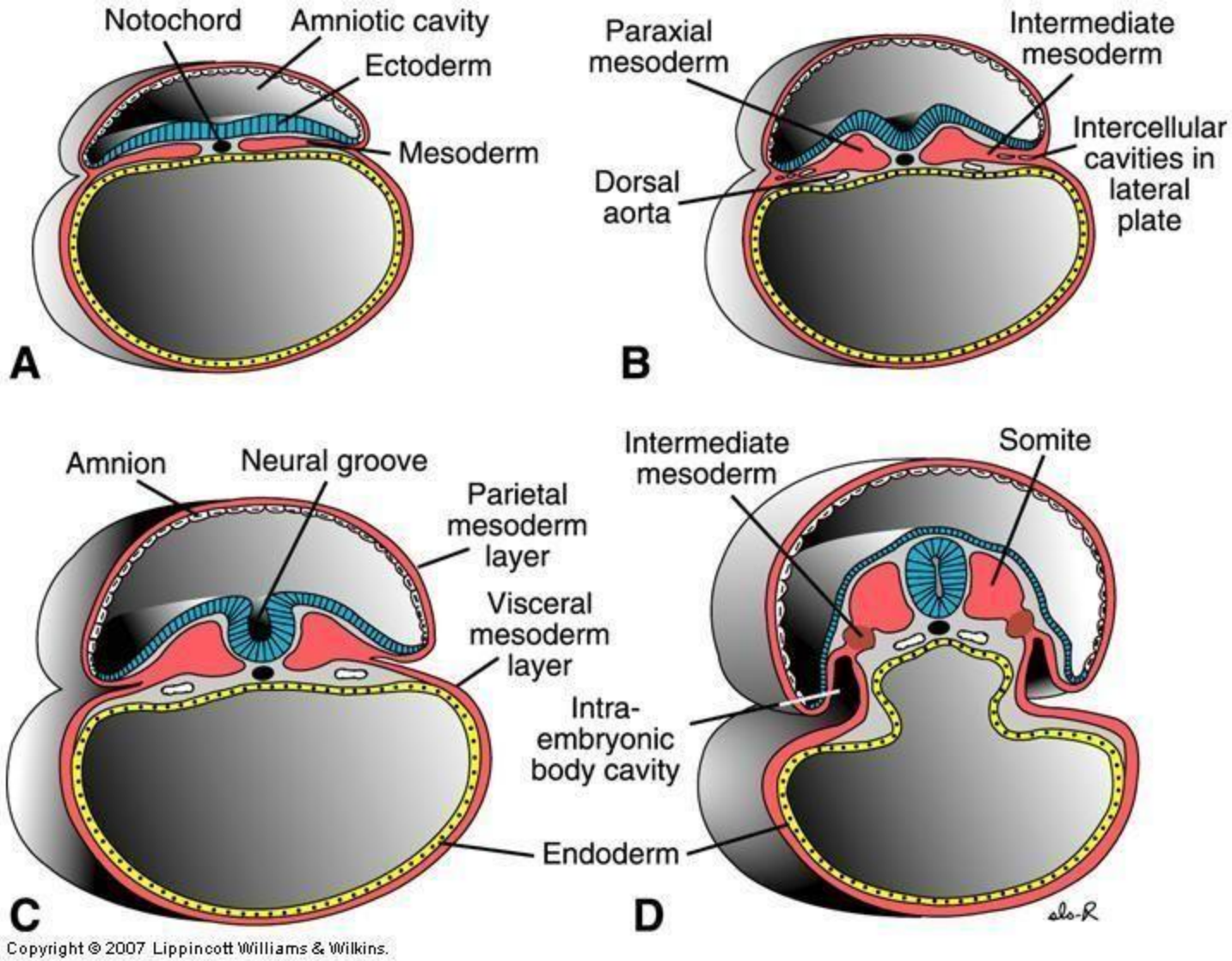
N.B. The intraembryonic mesoderm is differentiated into 3 regions:

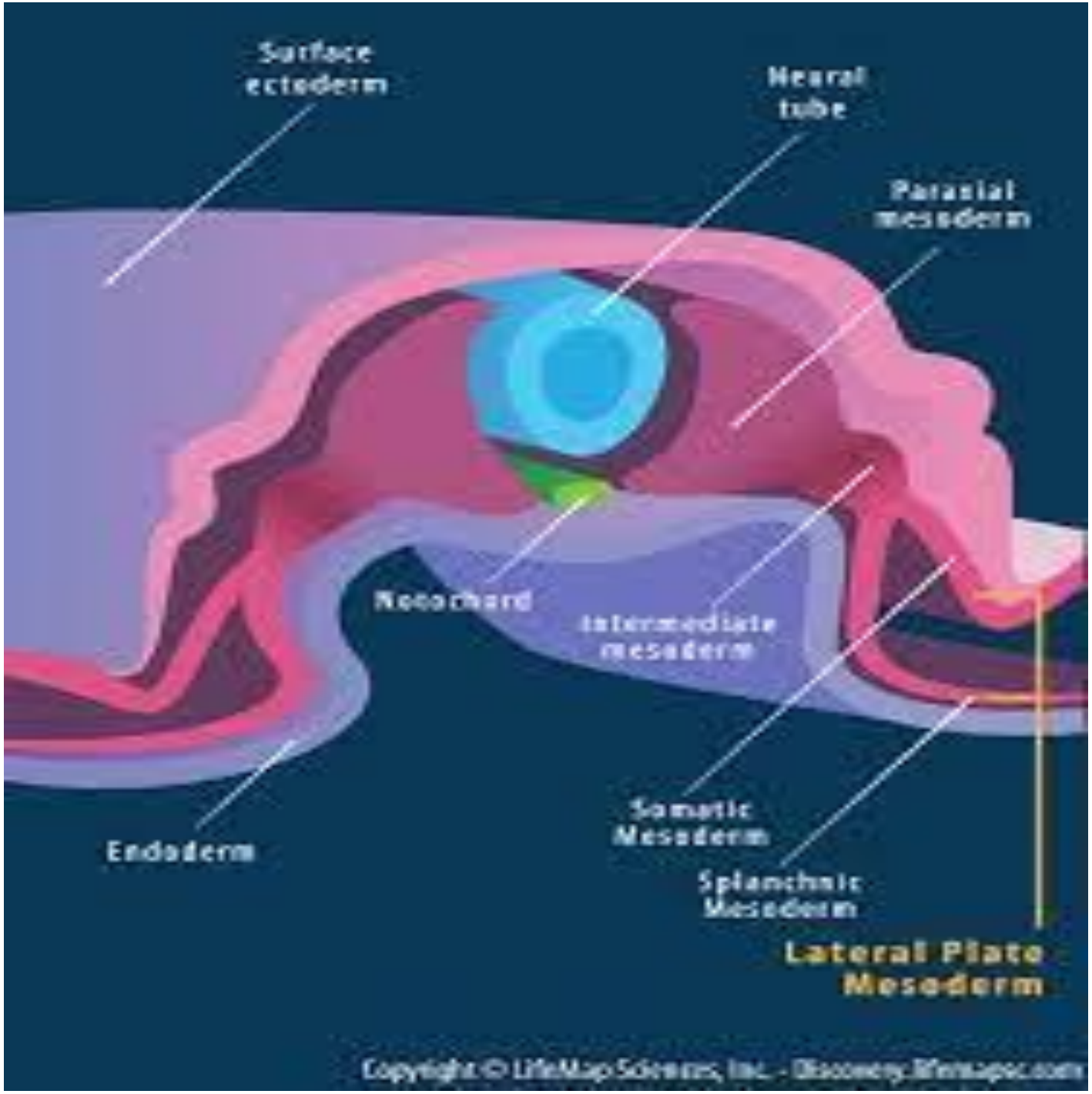
A-Paraxial mesoderm.

B-Intermediate mesoderm.

C-Lateral plate mesoderm.


Intermediate mesoderm
Paraxial mesoderm
Lateral plate mesoderm
Notochord
Extraembryonic mesoderm




Surface ectoderm
Neural tube
Parasial mesoderm
Notochord
Intermediate mesoderm
Endoderm
Somatic Mesoderm
Splanchnic Mesoderm
Lateral Plate Mesoderm
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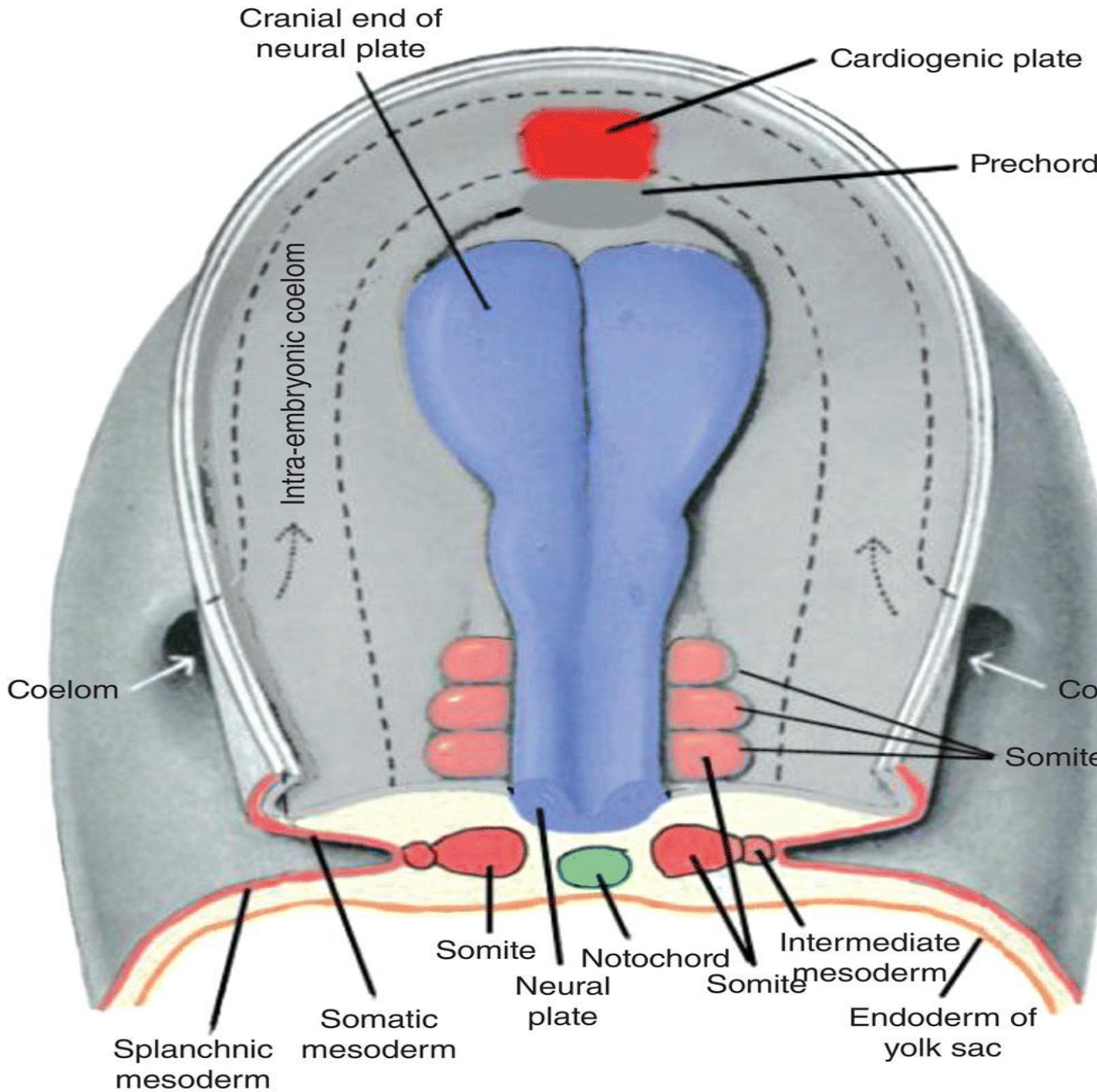
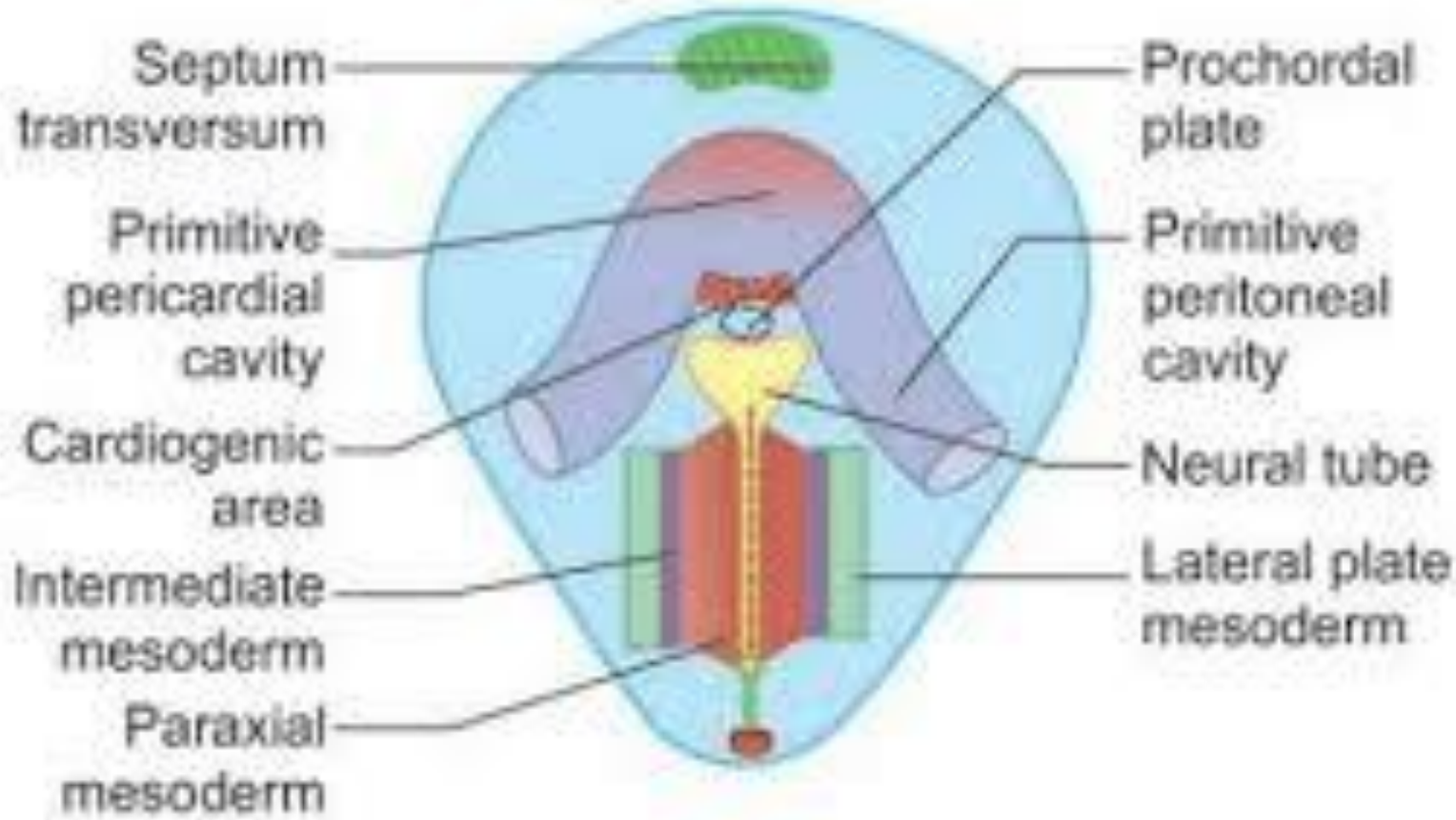
DEVELOPMENT OF THE INTRAEMBRYONIC COELOM

•The primordium of the intraembryonic coelom (embryonic body cavity) appears as isolated *coelomic spaces* in the lateral mesoderm and cardiogenic (heart-forming) mesoderm. These spaces soon coalesce to form a single **horseshoe-shaped cavity,**

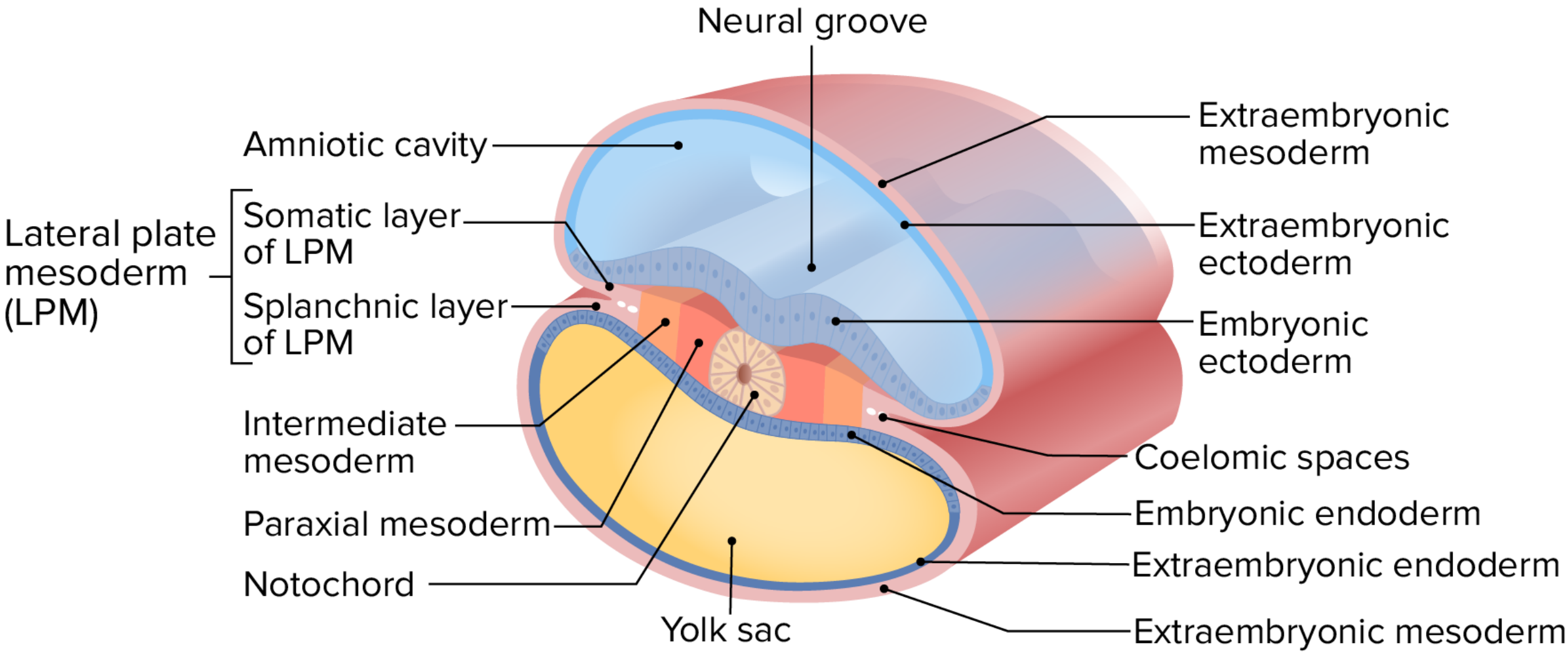



Septum transversum
Primitive pericardial cavity
Cardiogenic area
Intermediate mesoderm
Paraxial mesoderm
Prochordal plate
Primitive peritoneal cavity
Neural tube
Lateral plate mesoderm

•The **intraembryonic coelom**, divides the lateral mesoderm into two layers:

•**A somatic or *parietal layer*** of lateral mesoderm located beneath the ectodermal epithelium and continuous with the extraembryonic mesoderm covering the amnion.

•**A splanchnic or *visceral layer* of lateral mesoderm** located adjacent to the endoderm and continuous with the extraembryonic mesoderm **covering the Yolk sac(umbilical vesicle).**


Neural groove
Amniotic cavity
Lateral plate mesoderm (LPM)
Somatic layer of LPM
Splanchnic layer of LPM
Intermediate mesoderm
Paraxial mesoderm
Notochord
Yolk sac
Extraembryonic mesoderm
Extraembryonic ectoderm
Embryonic ectoderm
Coelomic spaces
Embryonic endoderm
Extraembryonic endoderm
Extraembryonic mesoderm

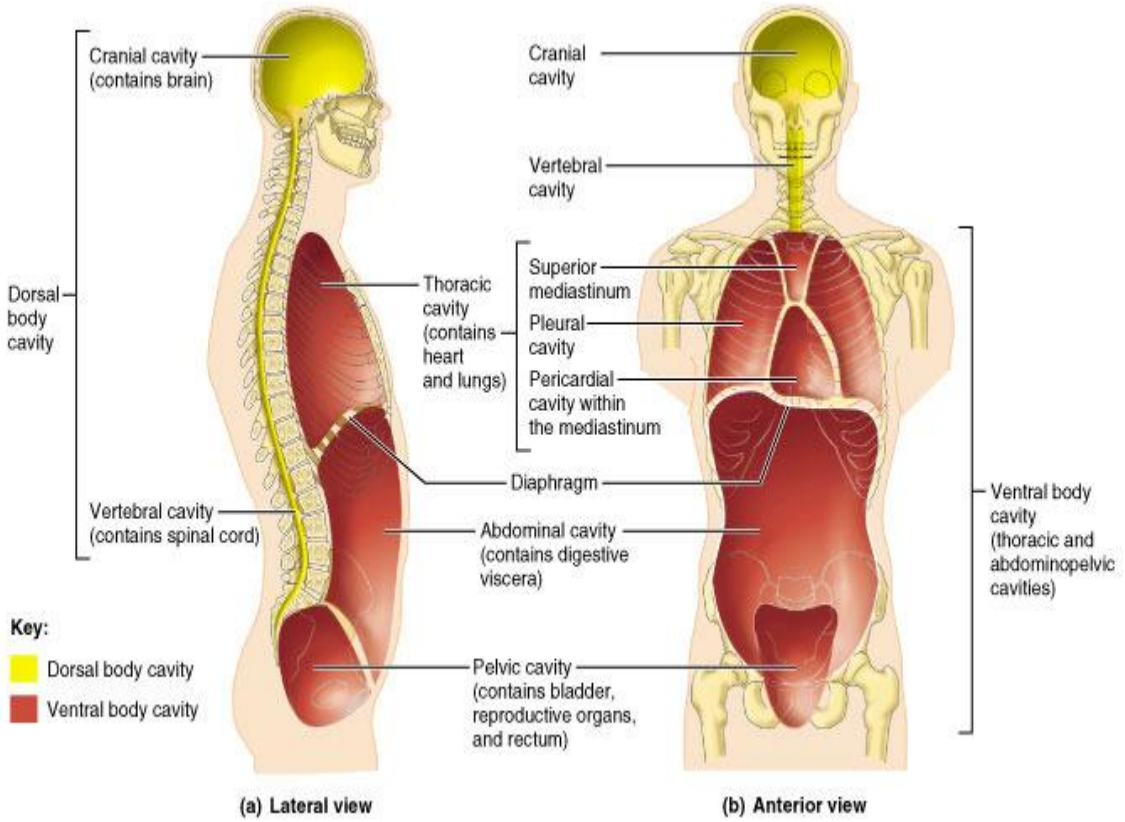
•**The somatic mesoderm and overlying embryonic ectoderm form the embryonic body wall or *somatopleure***, whereas the **splanchnic mesoderm and underlying embryonic endoderm form the embryonic gut or *splanchnopleure.***

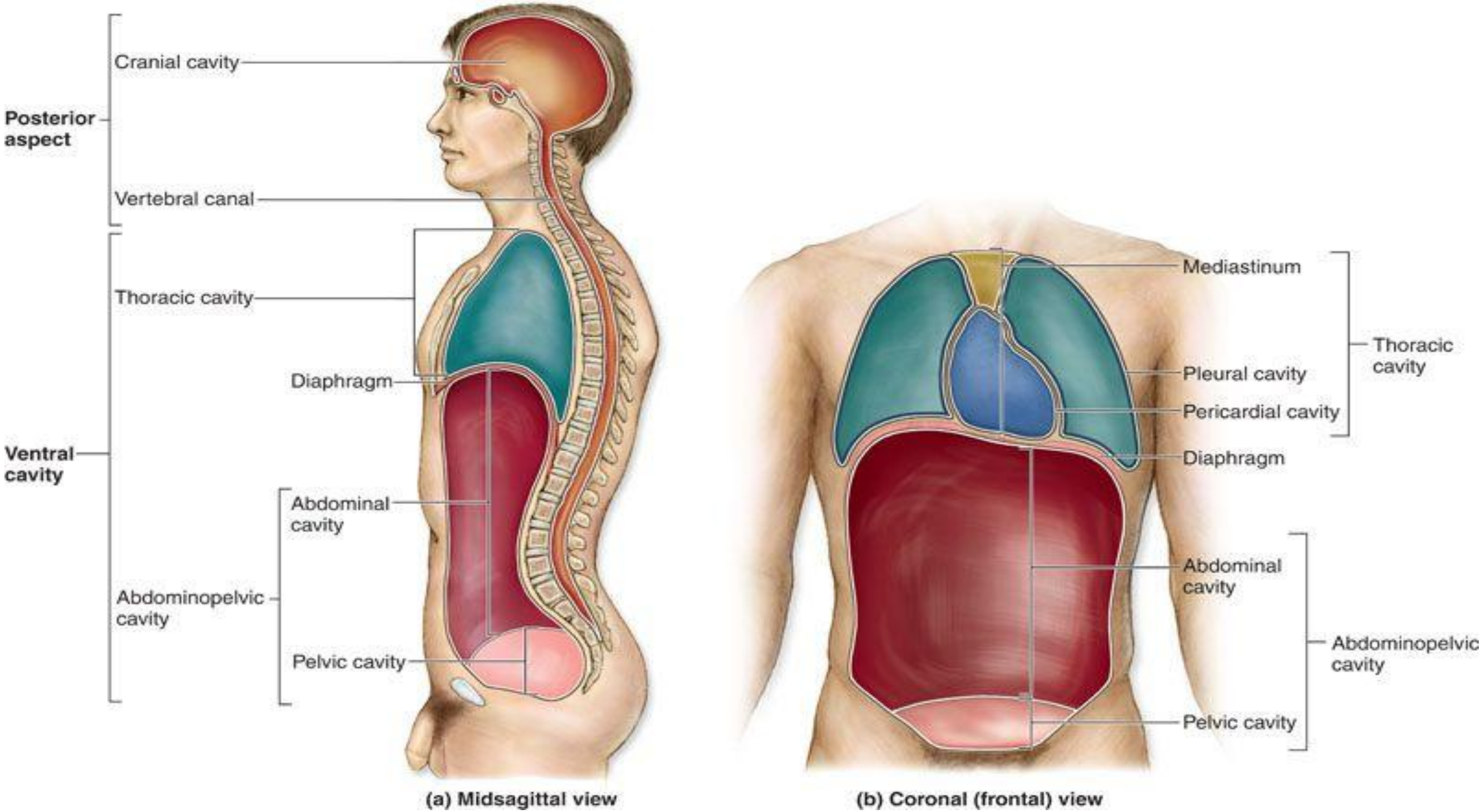
•During the second month, the intraembryonic coelom is divided into three body cavities:

•**Pericardial cavity**

•**Pleural cavities**

•**Peritoneal cavity**

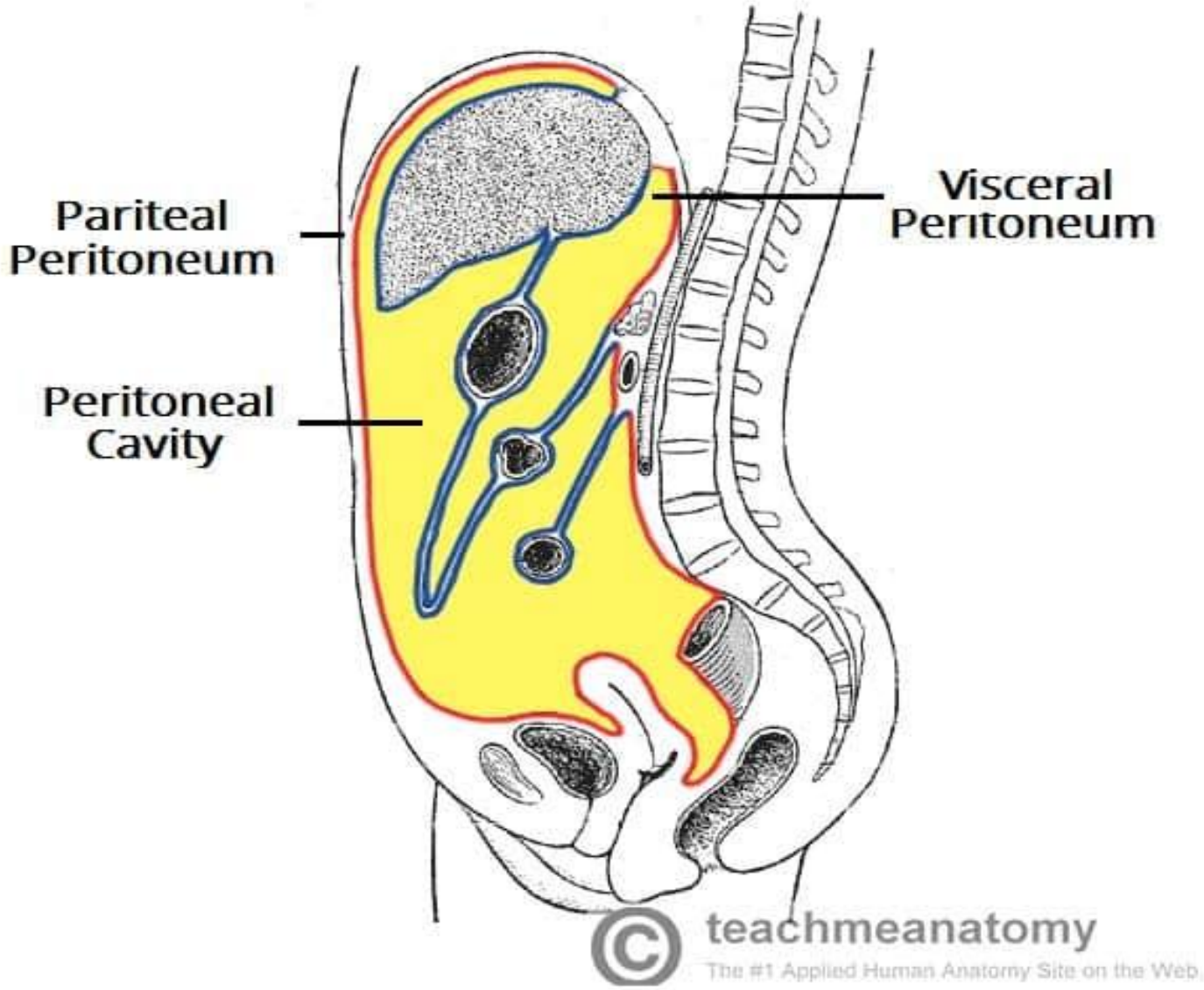


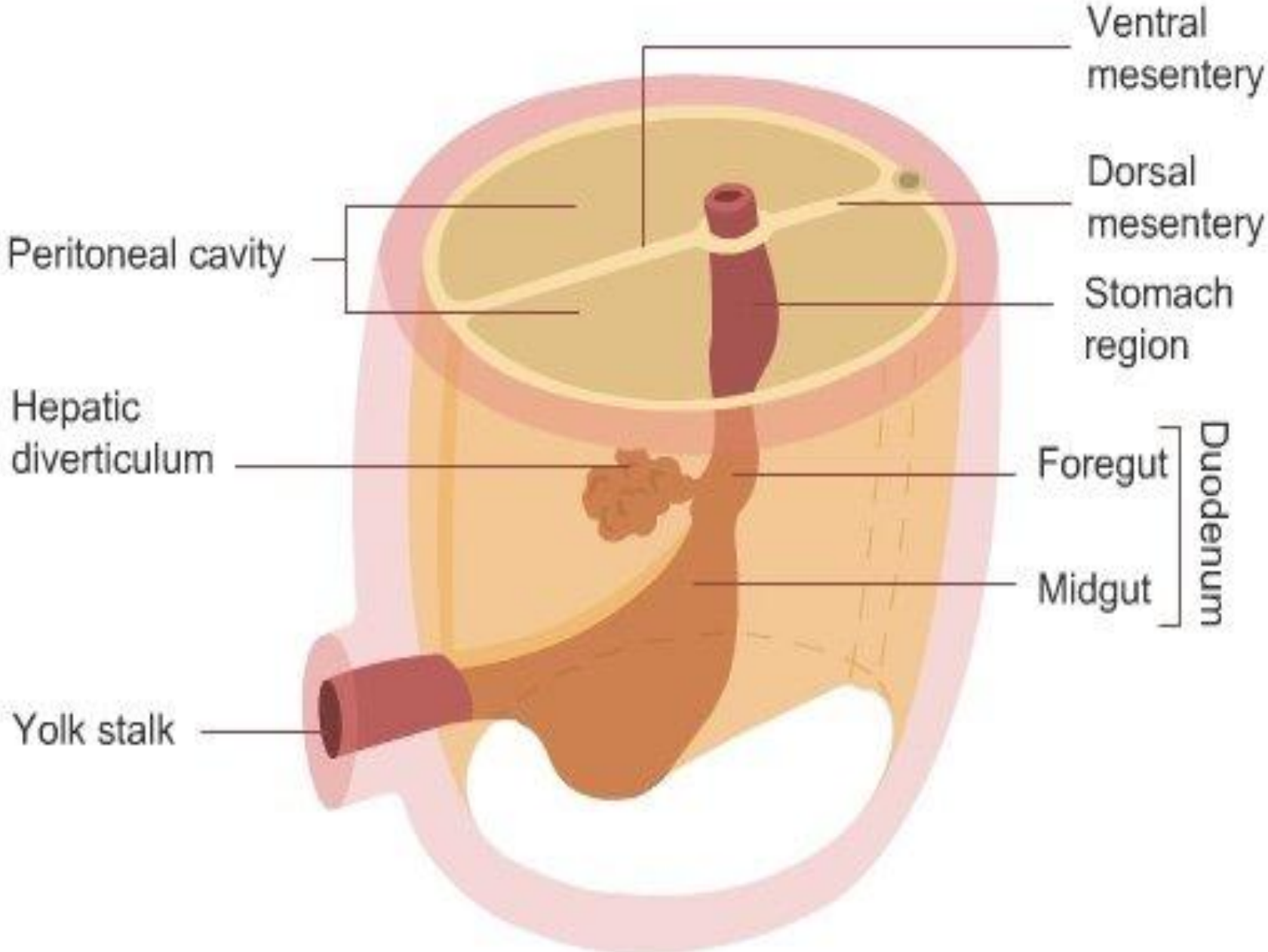


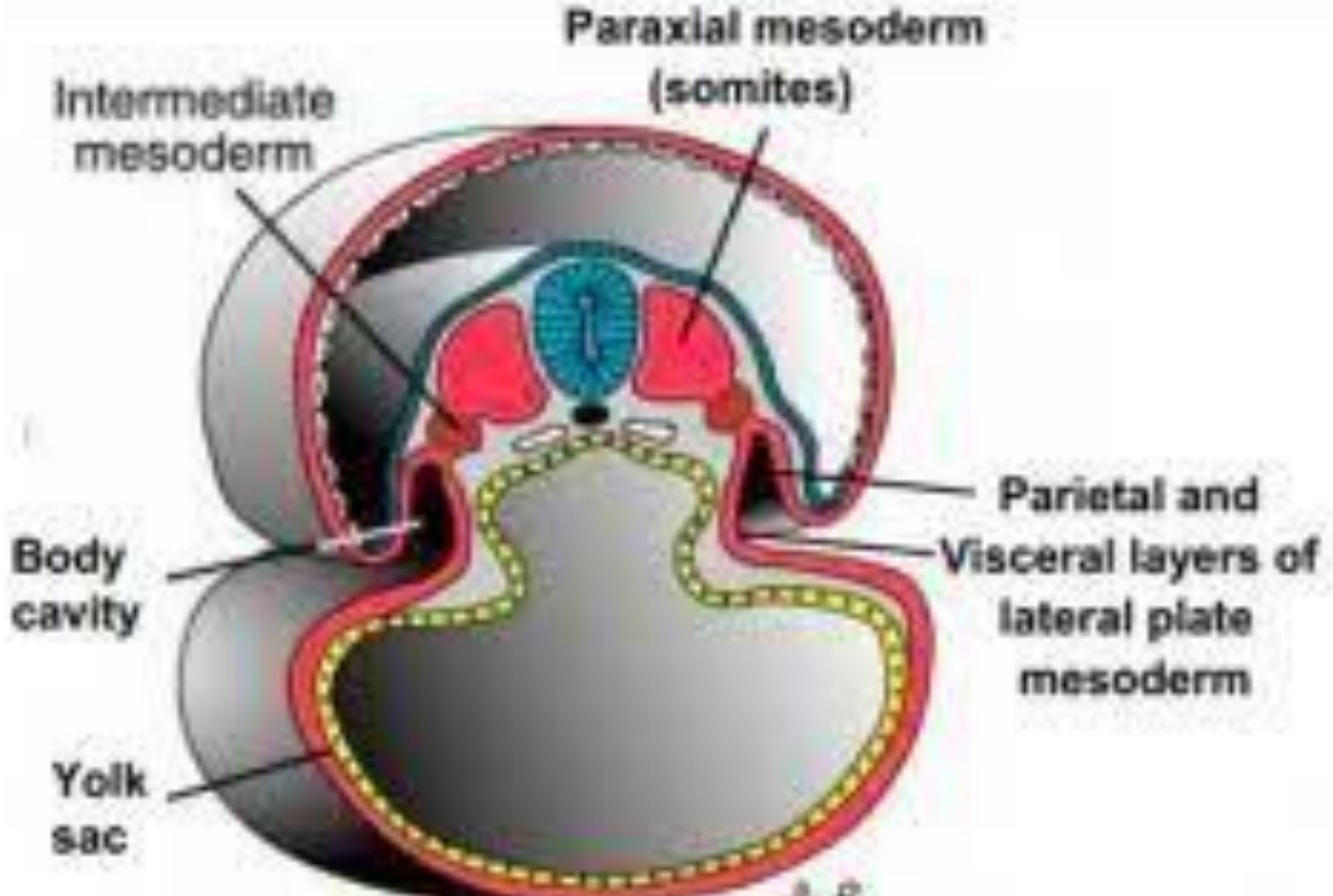
(a) Midsagittal view

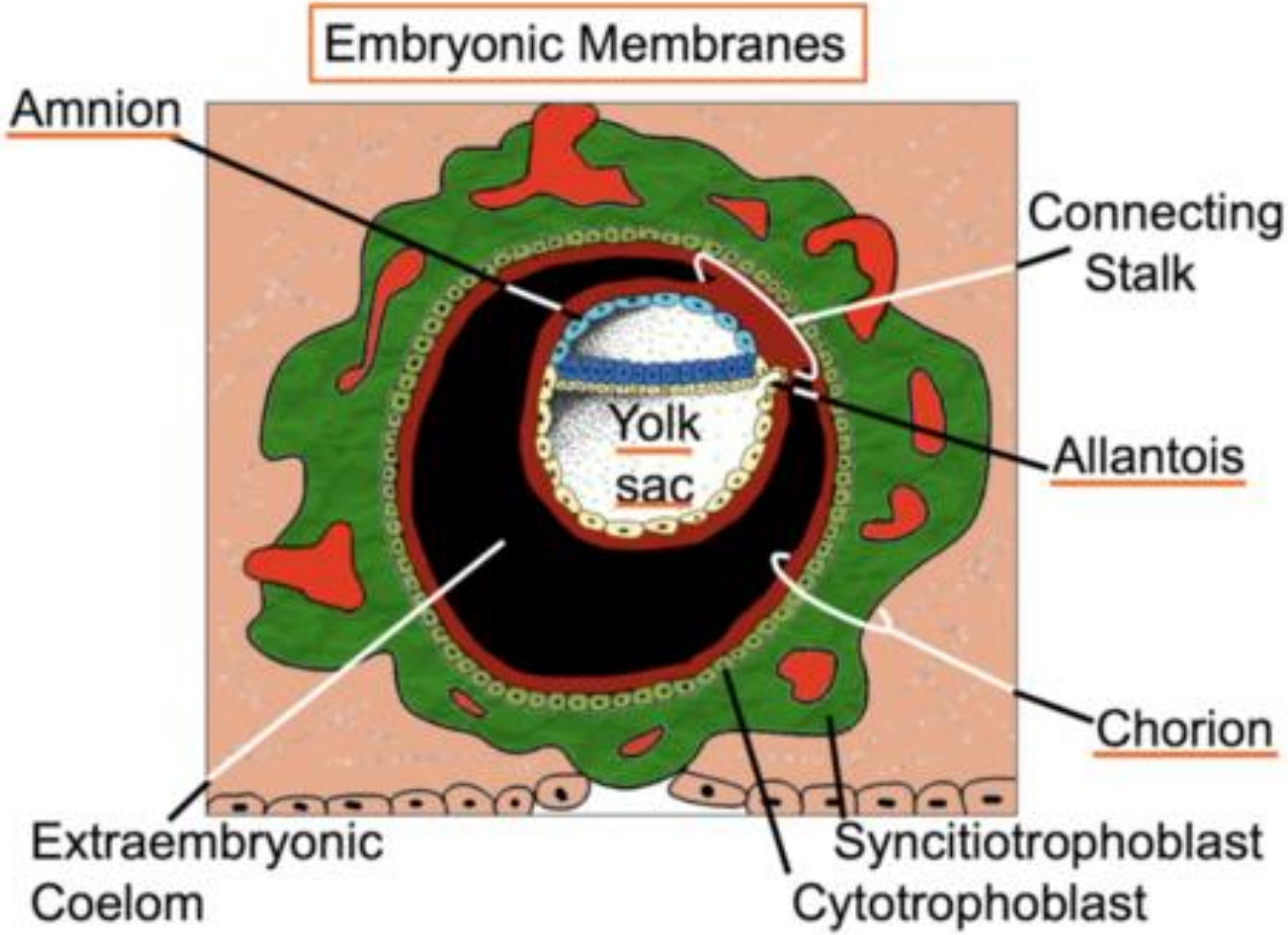
(b) Coronal (frontal) view

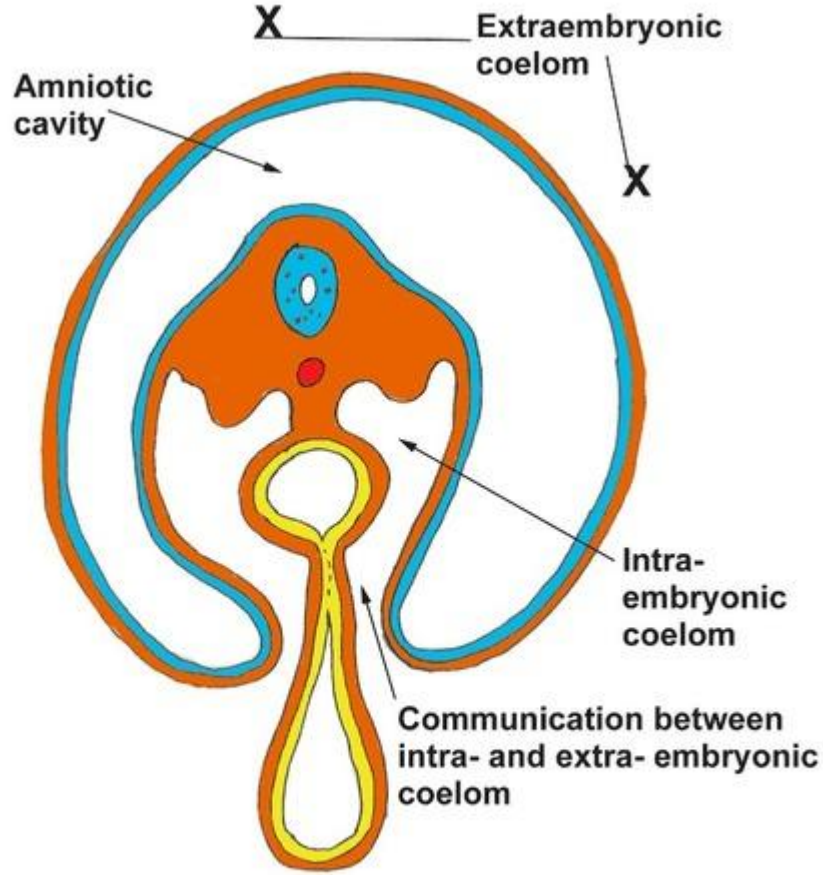
These body cavities have a **parietal wall lined by mesothelium (parietal layer of peritoneum) derived from somatic mesoderm and a visceral wall covered by mesothelium (visceral layer of peritoneum) derived from splanchnic mesoderm** .




Ventral mesentery
Dorsal mesentery
Peritoneal cavity
Stomach region
Hepatic diverticulum
Foregut
Duodenum
Midgut
Yolk stalk


Paraxial mesoderm
(somites)
Intermediate
mesoderm
Parietal and
Visceral layers of
lateral plate
mesoderm
Body
cavity
Yolk
sac

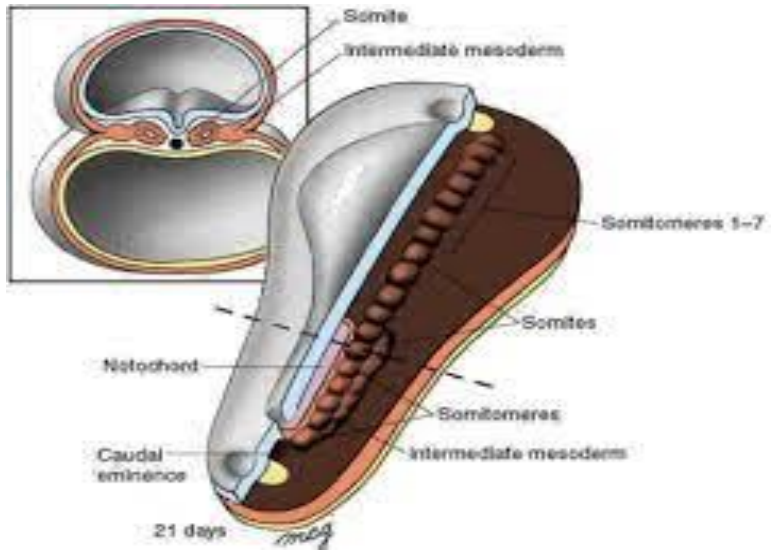

Embryonic Membranes
Amnion
Connecting Stalk
Yolk sac
Allantois
Chorion
Extraembryonic Coelom
Syncitiotrophoblast
Cytotrophoblast

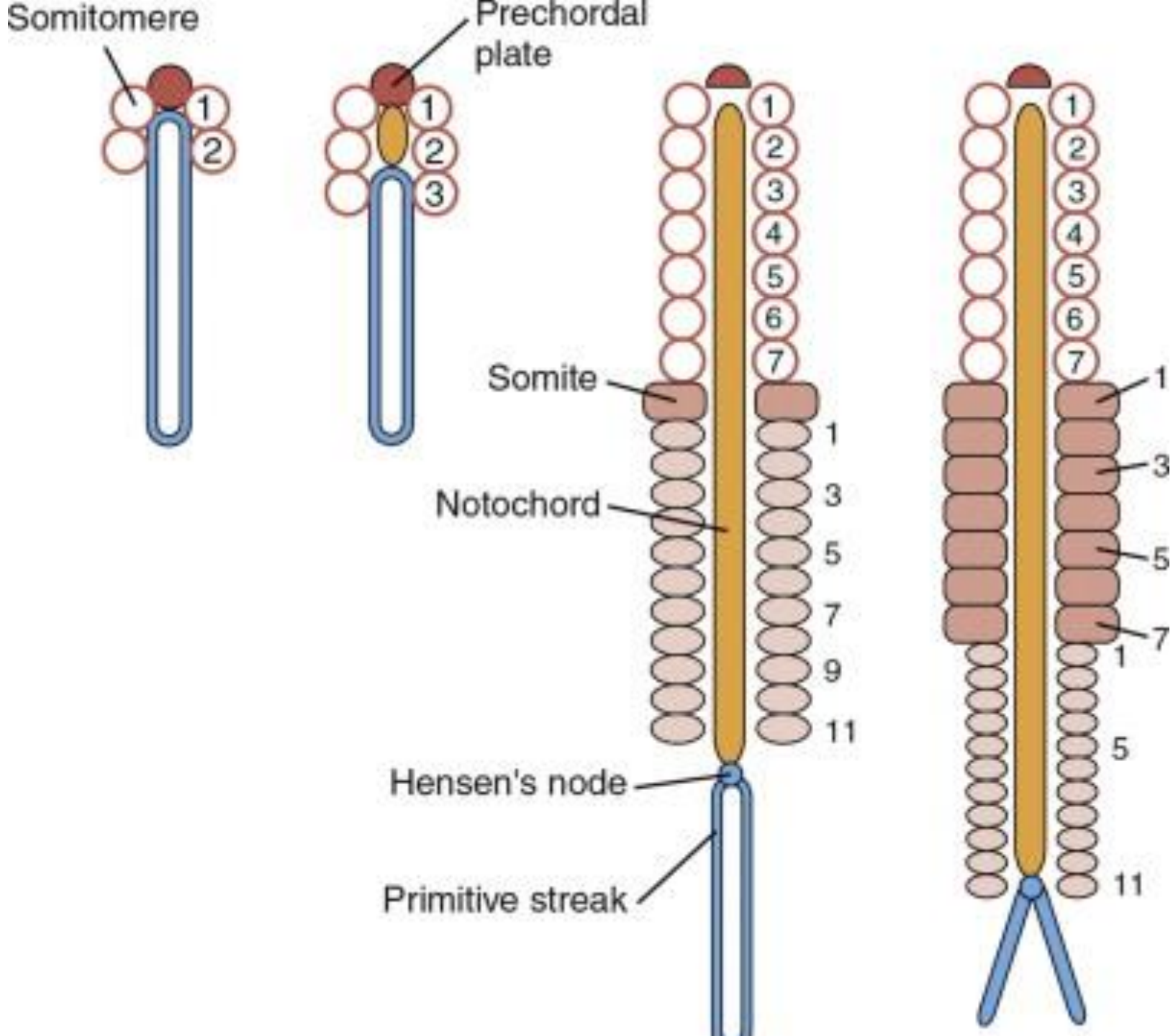

X
Extraembryonic coelom
Amniotic cavity
X
Intra-embryonic coelom
Communication between intra- and extra- embryonic coelom

1- Paraxial mesoderm

1- At the third week, the paraxial mesoderm begins to be arranged into segments.

2- These segments are called **somitomeres** and appear first in the cephalic region of the embryo. Their formation extend **caudally**. It consists of mesodermal cells arranged around center.




Somitomere
Prechordal plate
Somite
Notochord
Hensen's node
Primitive streak
1
2
3
4
5
6
7
9
11

3- The first pair of somites arises in **the occipital region of the embryo** at approximately **the 20th day of development** . From here, new somites appear in craniocaudal sequence at a **rate of approximately three pairs per day.**

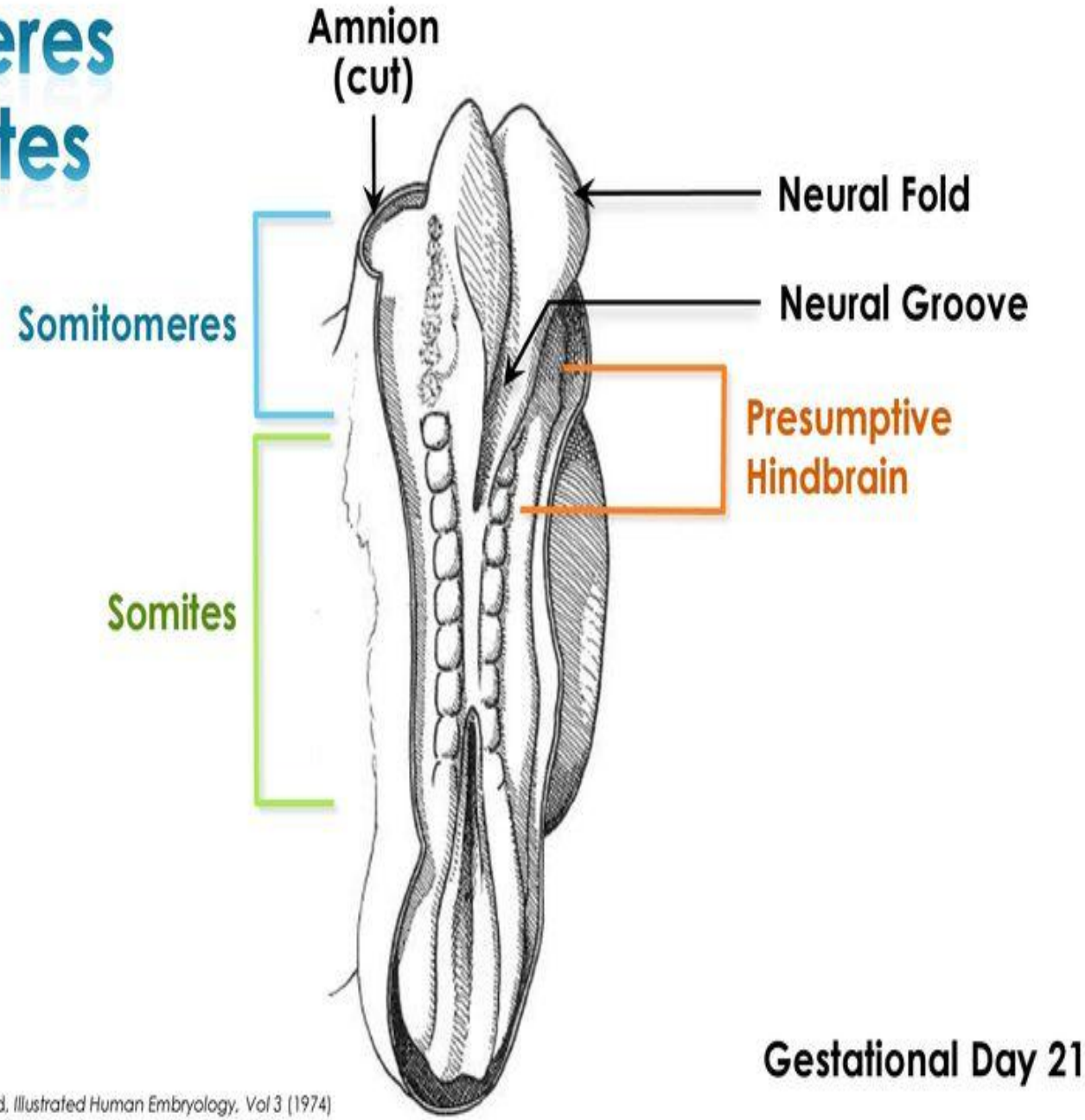
4-At the end of the fifth week, **42 to 44 pairs are present. There are 4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 8 to 10 coccygeal pairs.**

5- **The first occipital and the last five to seven coccygeal somites later disappear**, while the remaining somites form the axial skeleton .

6-The age of an embryo can be accurately determined during this early time by counting somites because somites appear in specified period.

Approximate age (days)	Number of somites
20	1-4
21	4-7
22	7-10

Somitomeres and Somites



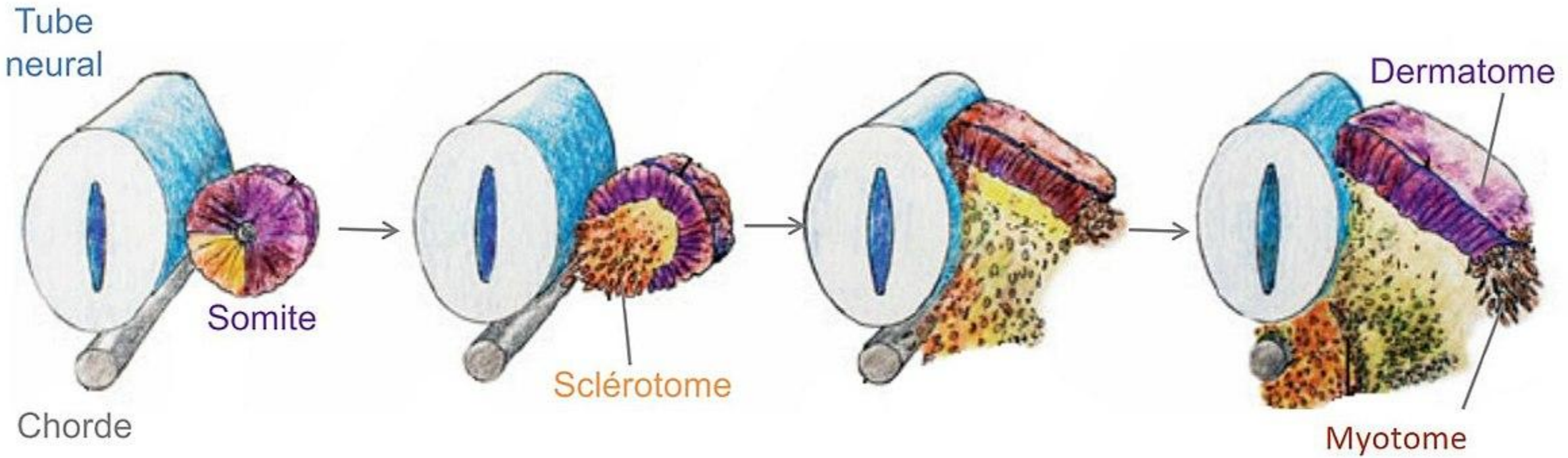
Gestational Day 21

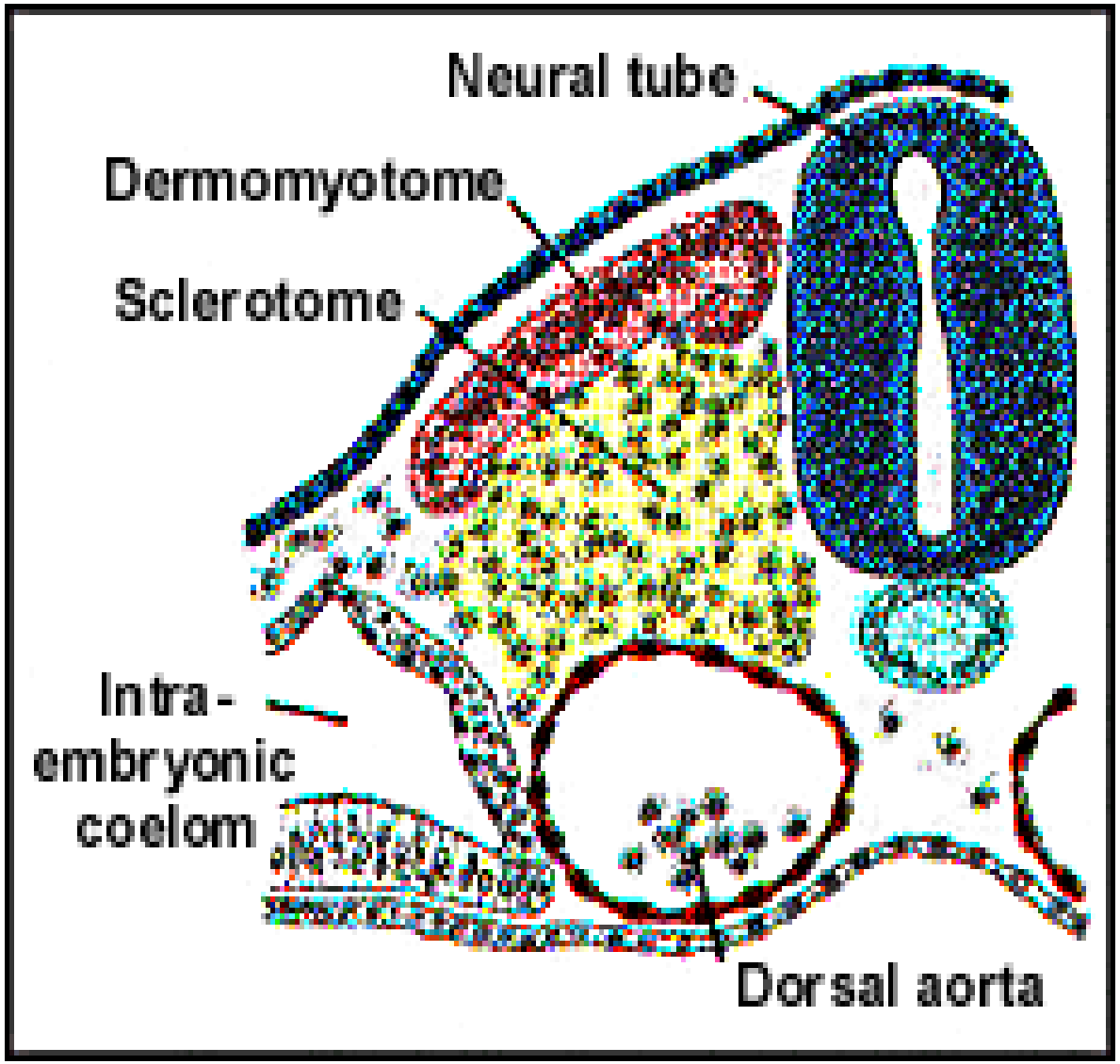
Modified from: Tuchmann-Duplessis, Aroux, and David. *Illustrated Human Embryology*, Vol 3 (1974)

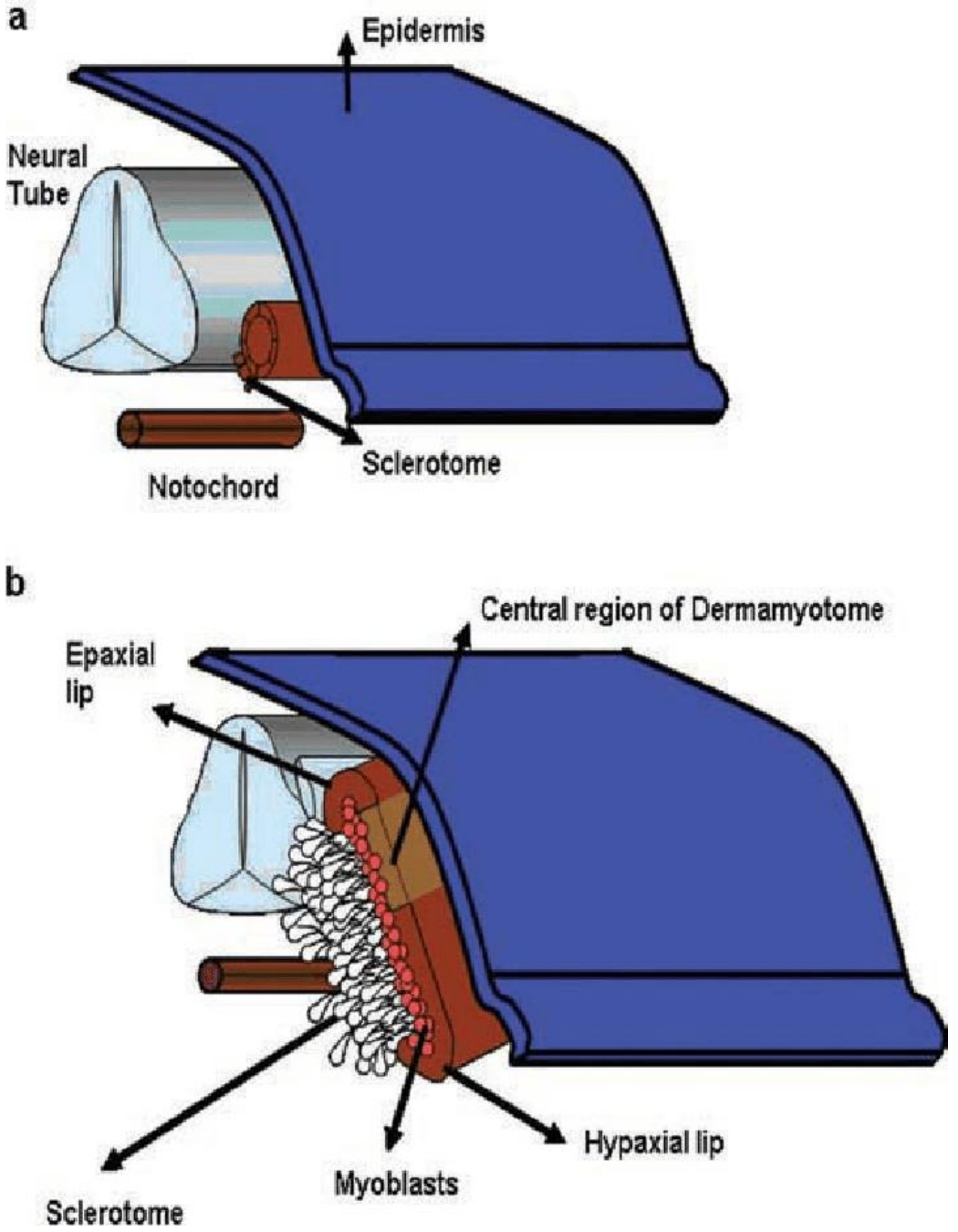
Somites differentiation:

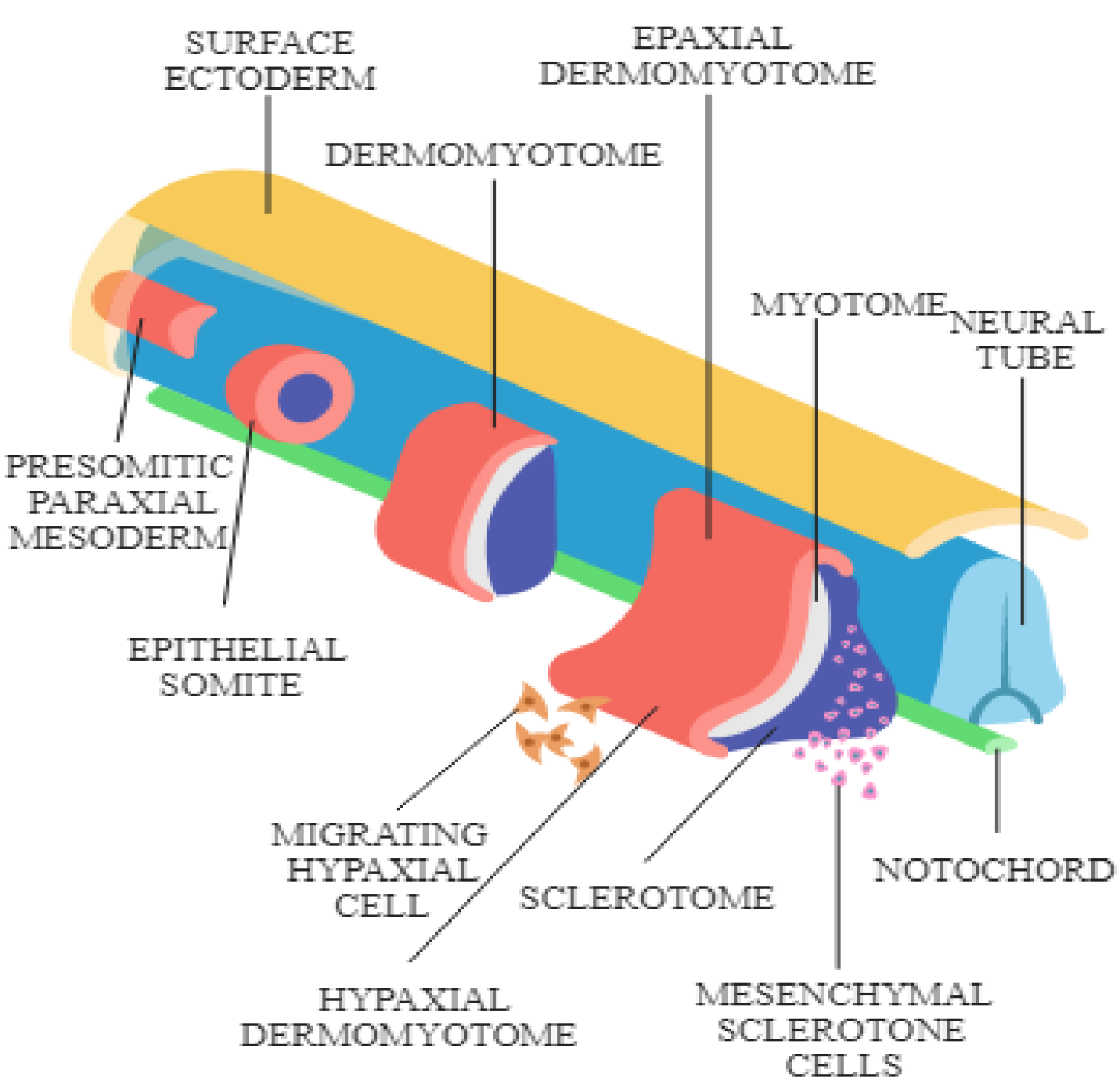
(A) When somites first form, they exist as a ball of mesoderm (fibroblast-like) cells. These cells arrange themselves in a donut shape around a small lumen.

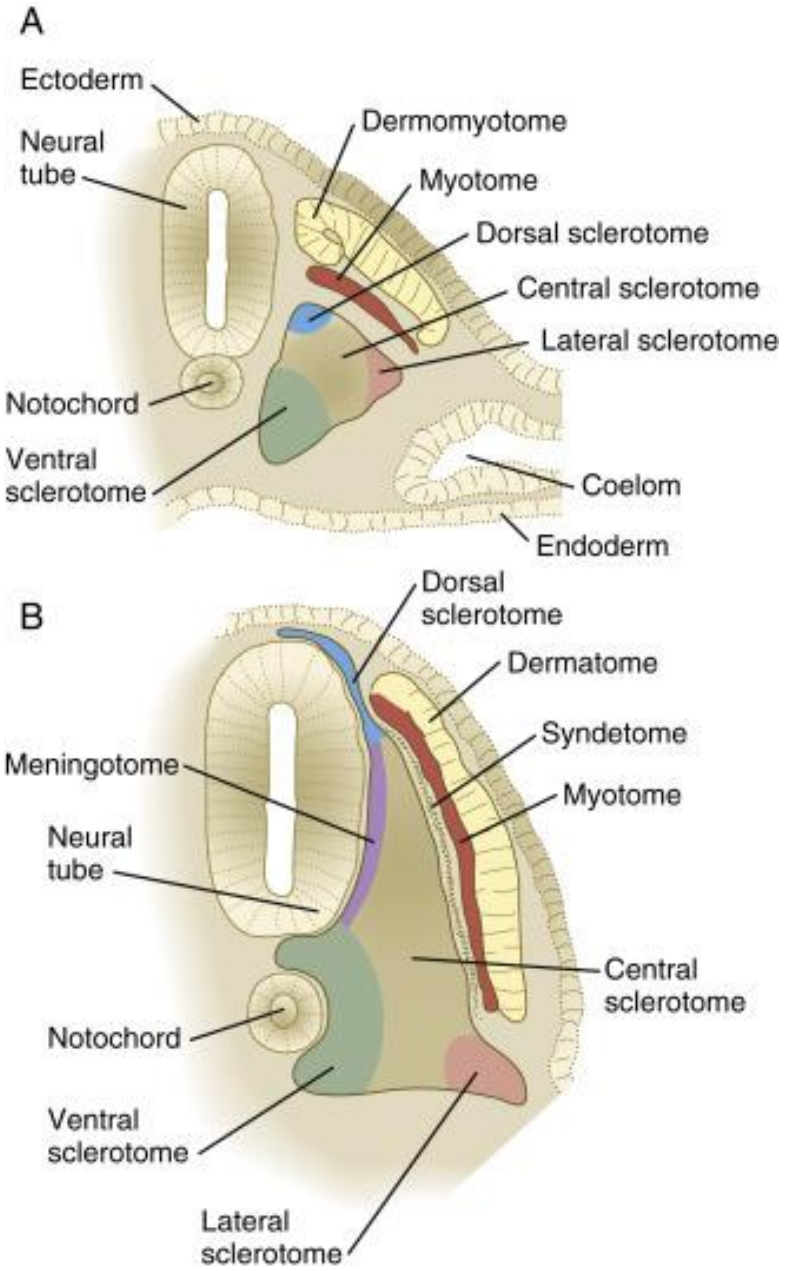
(B) **By the beginning of the fourth week**, cells of the somite shift their position to surround the neural tube and notochord. Collectively, **these cells form the sclerotome that will differentiate into the vertebrae and ribs.**


Tube neural
Somite
Chorde
Sclérotome
Dermatome
Myotome

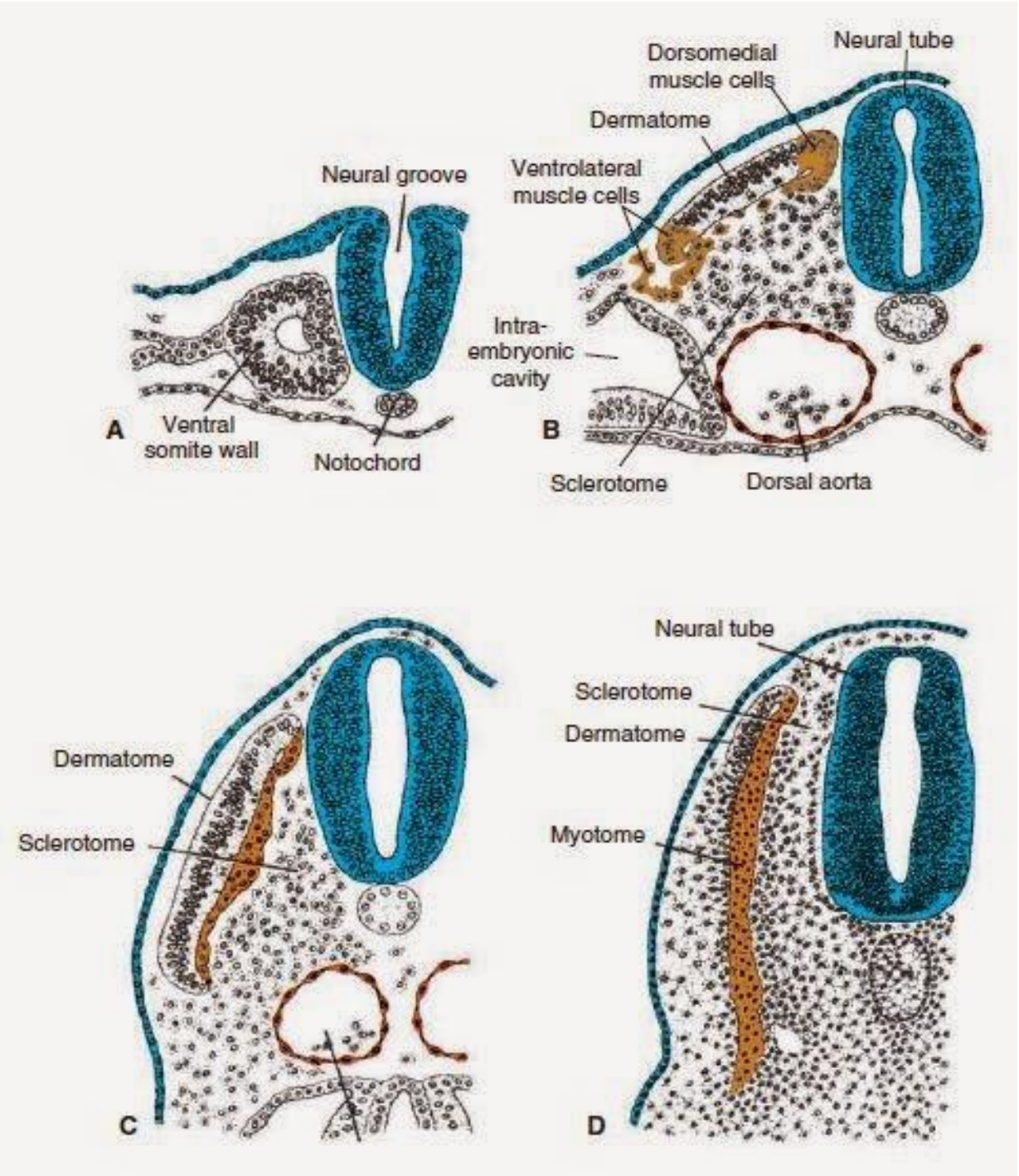

Neural tube
Dermomyotome
Sclerotome
Intra-
embryonic
coelom
Dorsal aorta

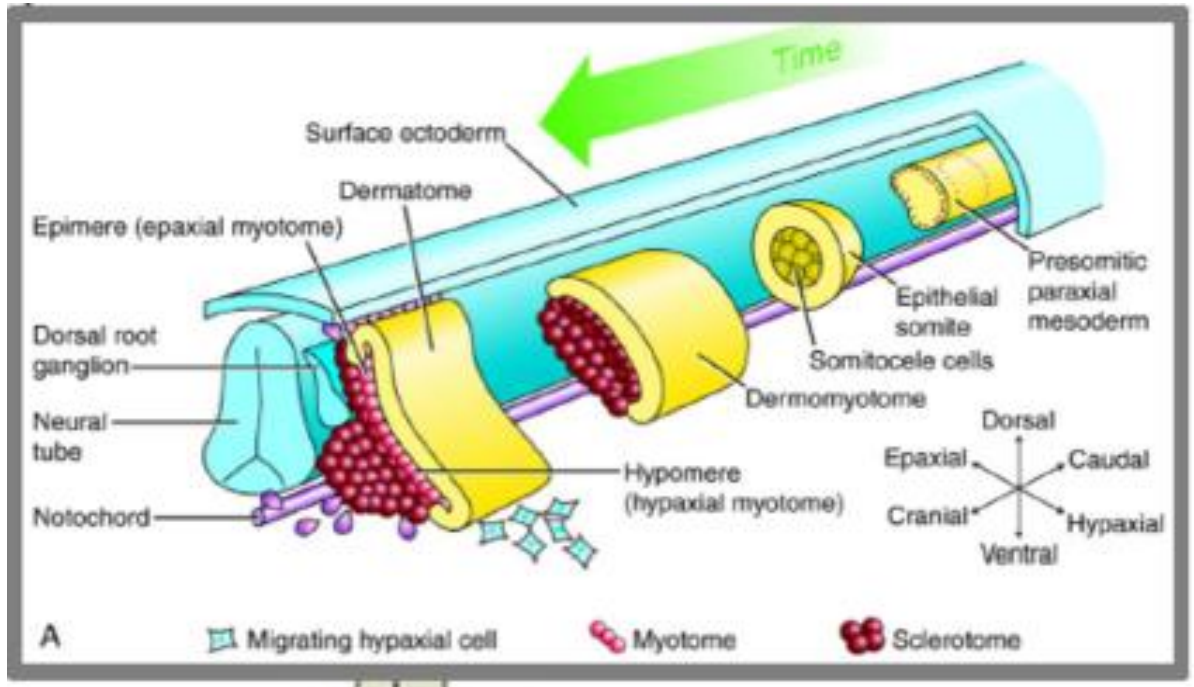

a
Epidermis
Neural
Tube
Notochord
Sclerotome
b
Central region of Dermamyotome
Epaxial
lip
Hypaxial lip
Myoblasts
Sclerotome

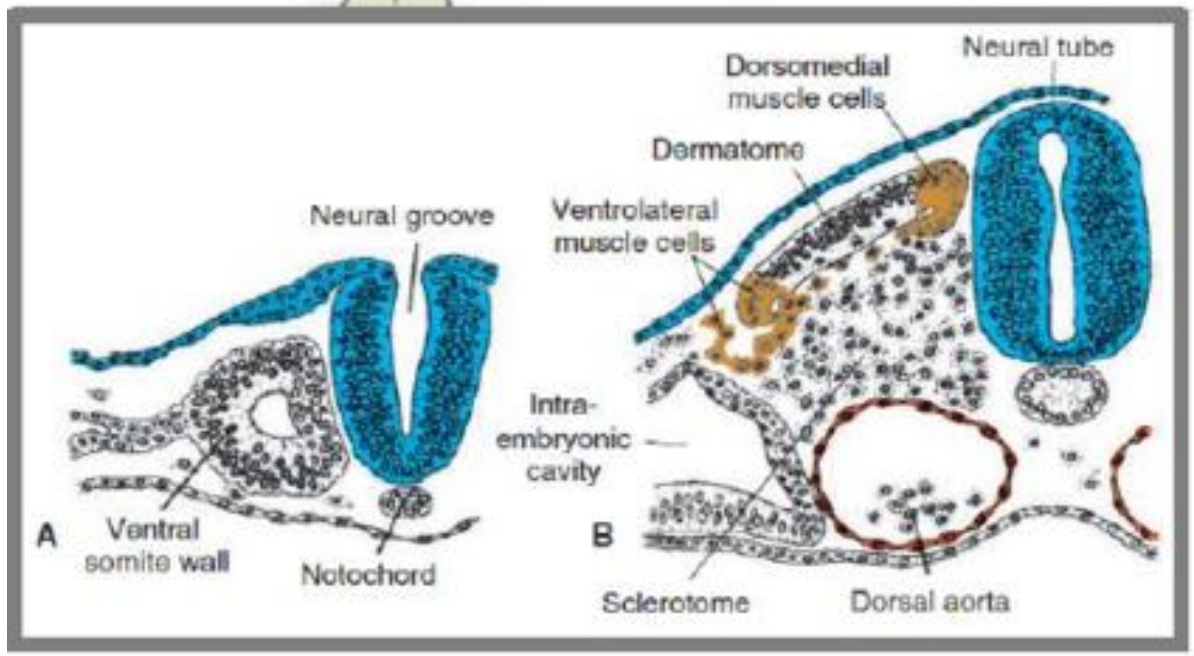

SURFACE ECTODERM
EPAXIAL DERMOMYOTOME
DERMOMYOTOME
MYOTOME
NEURAL TUBE
PRESOMITIC PARAXIAL MESODERM
EPITHELIAL SOMITE
MIGRATING HYPAXIAL CELL
SCLEROTOME
NOTOCHORD
HYPAXIAL DERMOMYOTOME
MESENCHYMAL SCLEROTONE CELLS


A
Ectoderm
Neural tube
Dermomyotome
Myotome
Dorsal sclerotome
Central sclerotome
Lateral sclerotome
Notochord
Ventral sclerotome
Coelom
Endoderm
B
Dorsal sclerotome
Dermatome
Syndetome
Meningotome
Myotome
Neural tube
Central sclerotome
Notochord
Ventral sclerotome
Lateral sclerotome

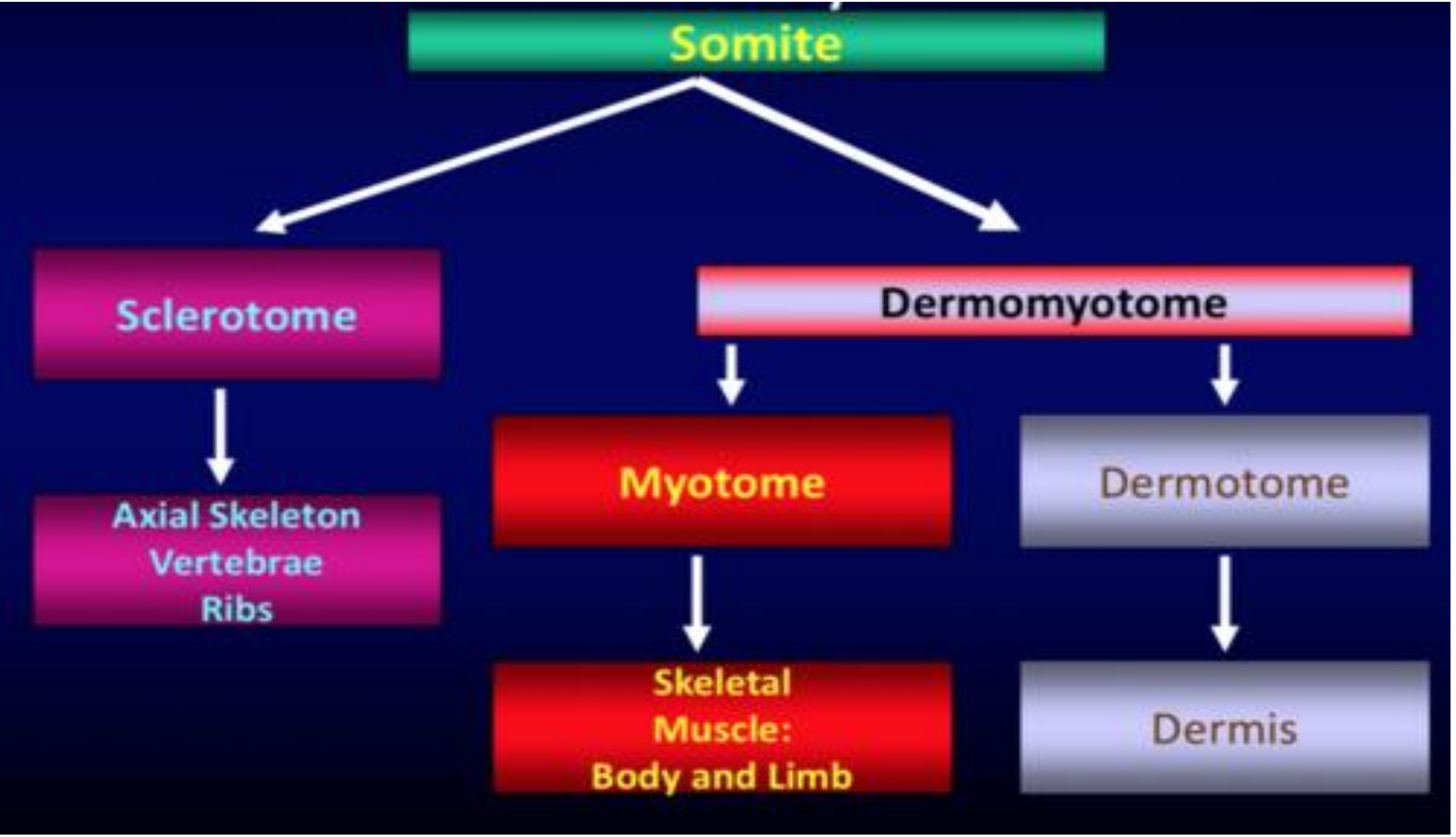
(C) Cells at the **dorsomedial and ventrolateral edges** of the upper region of the somite form (**Myotomes) precursors** for **muscle cells,** while cells between these two groups form the **dermatome**. Cells from the **ventrolateral edge migrate into the parietal layer of lateral plate mesoderm to form most of the musculature for the body wall (external and internal oblique and transversus abdominis muscles) and most of the limb muscles. Cells from the dorsomedial edge form muscles of the back.**


Neural groove
Ventral somite wall
Notochord
A
Dorsomedial muscle cells
Neural tube
Dermatome
Ventrolateral muscle cells
Intra-embryonic cavity
Sclerotome
Dorsal aorta
B
Dermatome
Sclerotome
C
Neural tube
Sclerotome
Dermatome
Myotome
D


Time
Surface ectoderm
Dermatome
Epimere (epaxial myotome)
Presomitic paraxial mesoderm
Epithelial somite
Somitocele cells
Dorsal root ganglion
Dermomyotome
Neural tube
Hypomere (hypaxial myotome)
Notochord
Dorsal
Epaxial
Caudal
Cranial
Hypaxial
Ventral
A
Migrating hypaxial cell
Myotome
Sclerotome


Neural groove
Ventral somite wall
Notochord
A
Dorsomedial muscle cells
Neural tube
Dermatome
Ventrolateral muscle cells
Intra-embryonic cavity
Sclerotome
Dorsal aorta
B

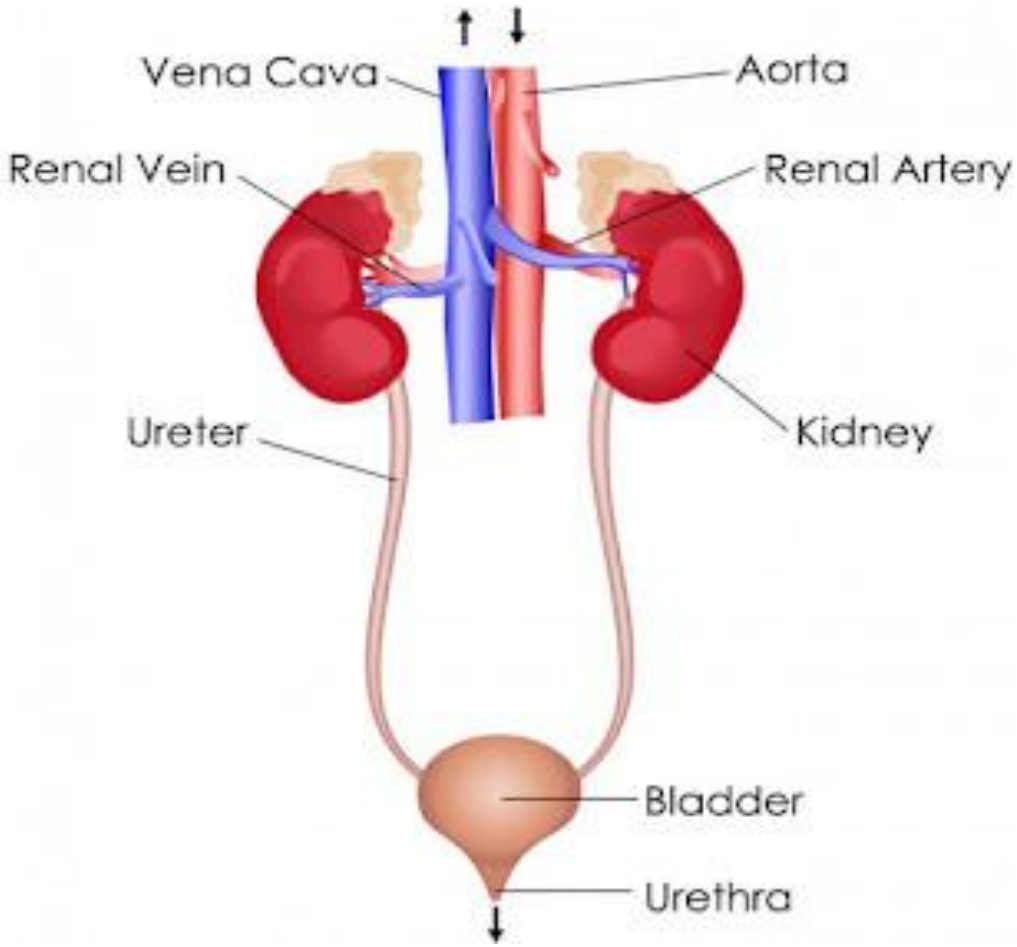
(D) **Each myotome and dermatome retains its innervation from its segment of origin, no matter where the cells migrate.** Hence, each somite forms its own sclerotome (the tendon, cartilage and bone component), its own myotome (providing the segmental muscle component), and its own dermatome, which forms the dermis of the skin . Each myotome and dermatome also has its own segmental nerve component.

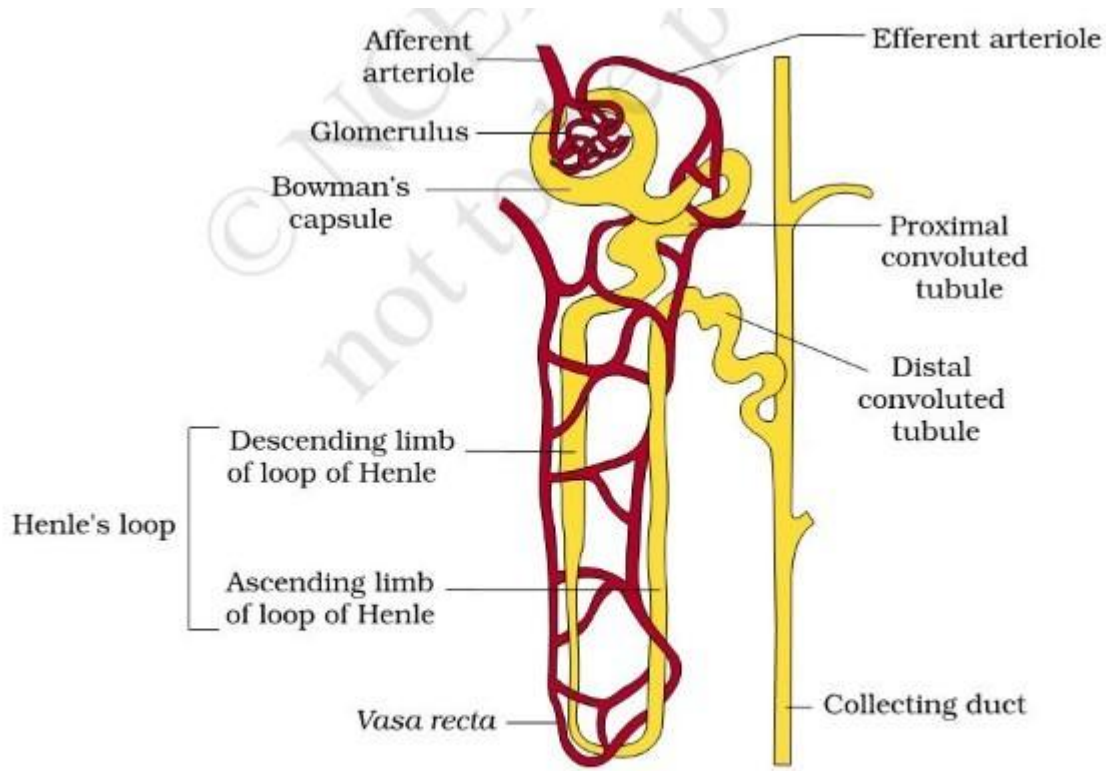

Somite
Sclerotome
Dermomyotome
Axial Skeleton
Vertebrae
Ribs
Myotome
Dermotome
Skeletal
Muscle:
Body and Limb
Dermis

2- Intermediate mesoderm

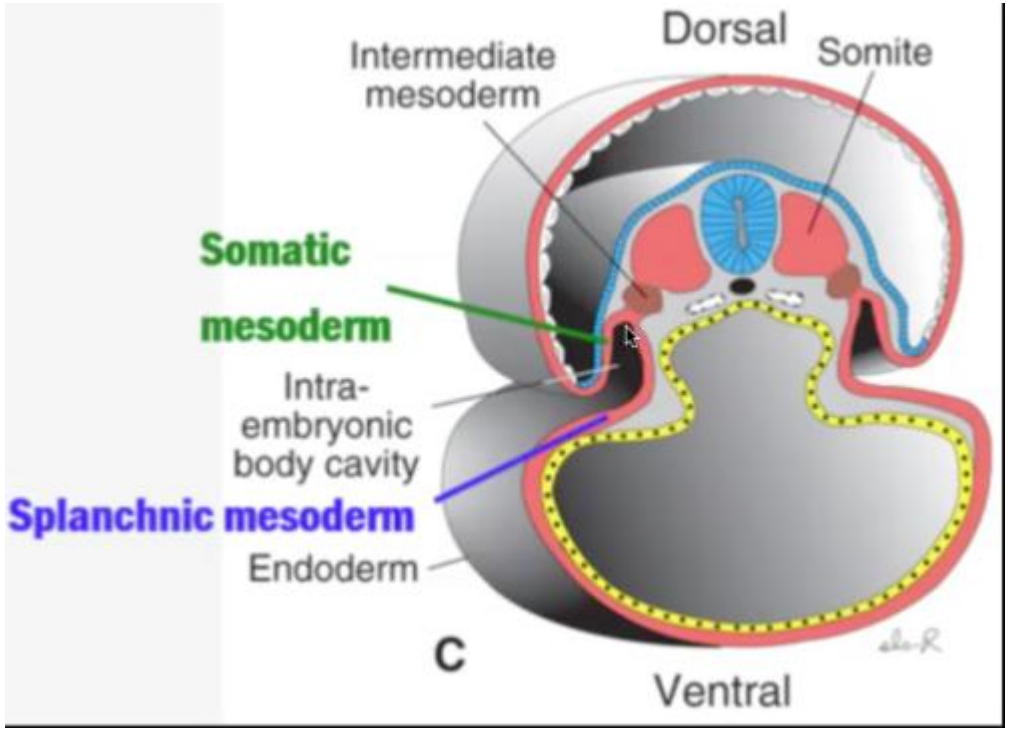
1-Intermediate mesoderm temporarily connects paraxial mesoderm with the lateral plate.

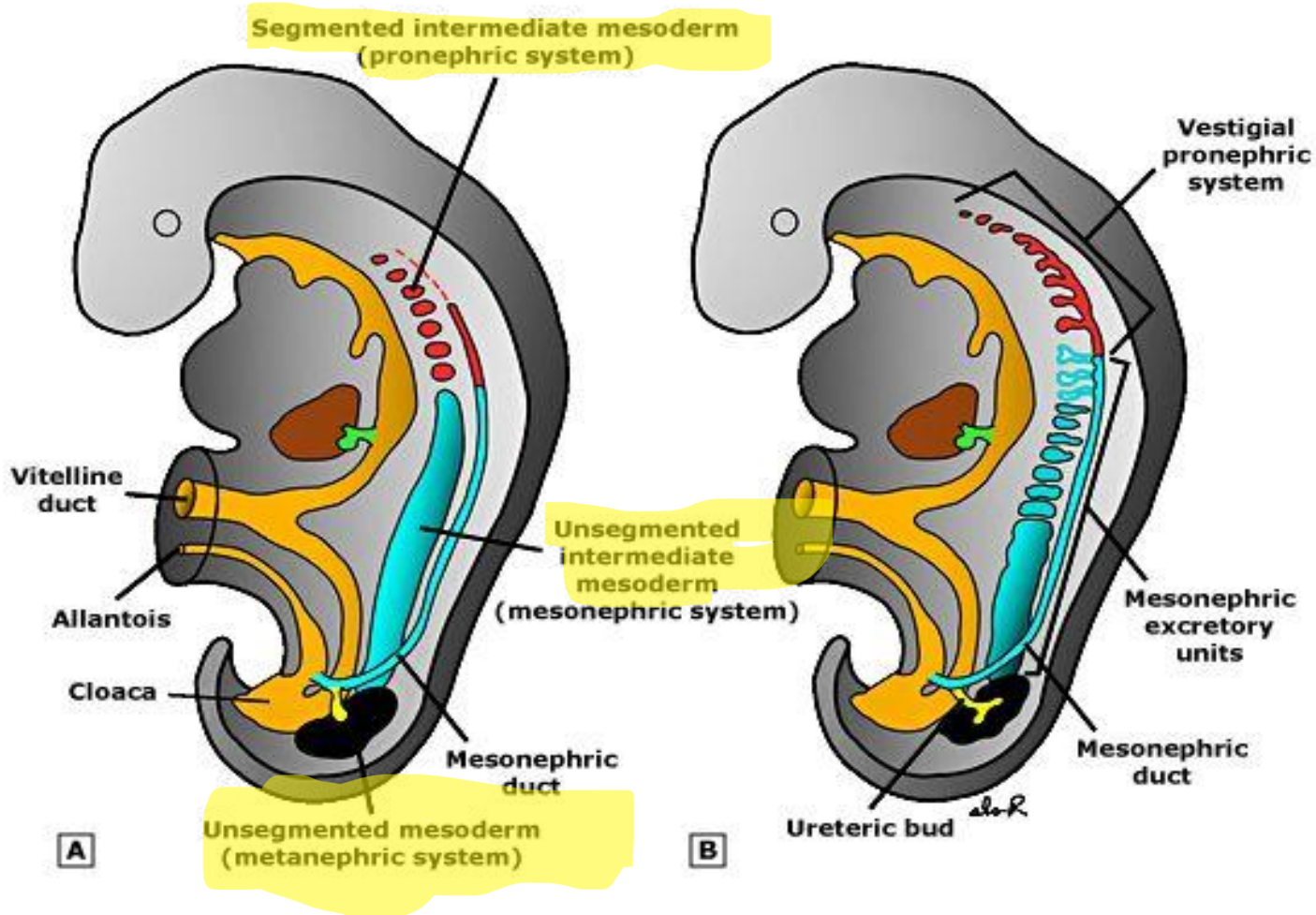
2- It differentiates into urogenital structures. In cephalic regions, it forms **segmental cell clusters (future nephrotomes)**, whereas more caudally, it forms an **unsegmented mass of tissue, the nephrogenic cord.**





A diagrammatic representation of a nephron showing blood vessels, duct and tubule


Dorsal
Intermediate mesoderm
Somite
Somatic mesoderm
Intra-embryonic body cavity
Splanchnic mesoderm
Endoderm
C
Ventral

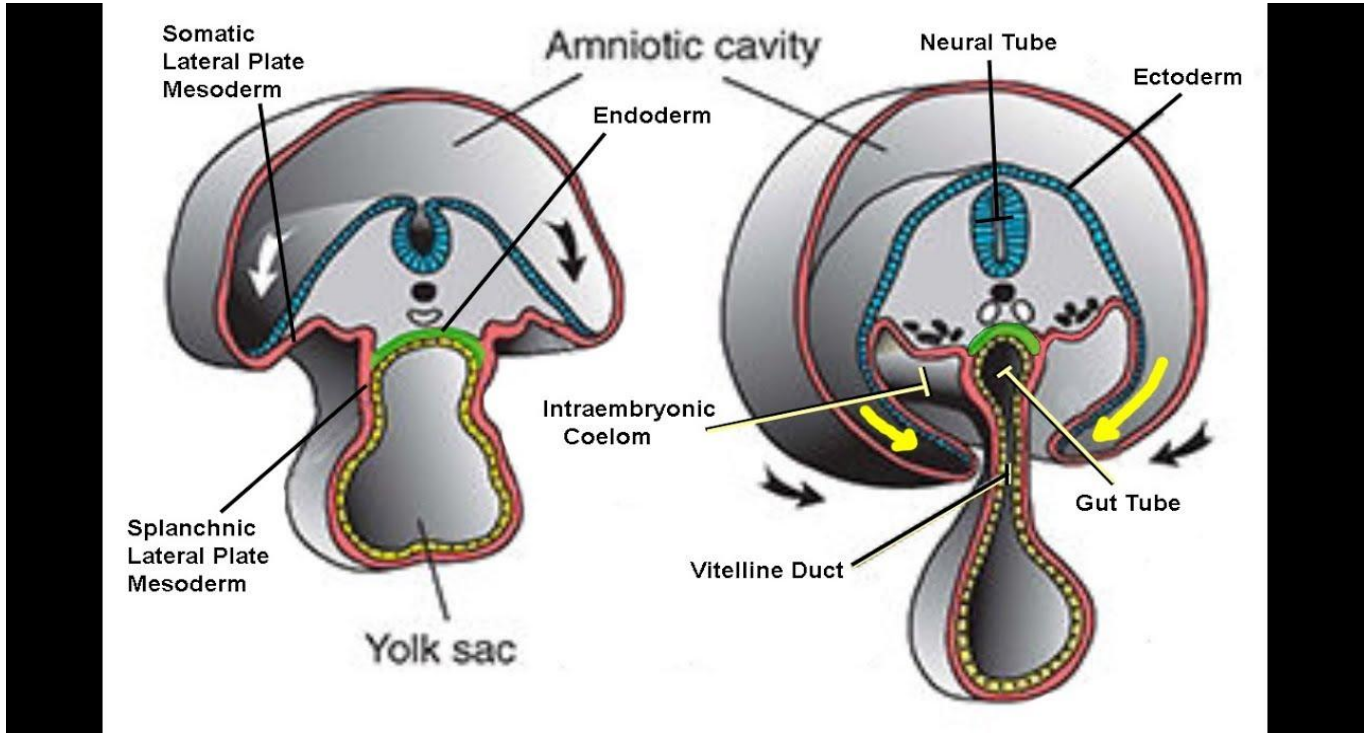

Segmented intermediate mesoderm (pronephric system)
Vitelline duct
Allantois
Cloaca
Unsegmented intermediate mesoderm (mesonephric system)
Mesonephric duct
Unsegmented mesoderm (metanephric system)
A
Vestigial pronephric system
Mesonephric excretory units
Mesonephric duct
Ureteric bud
B

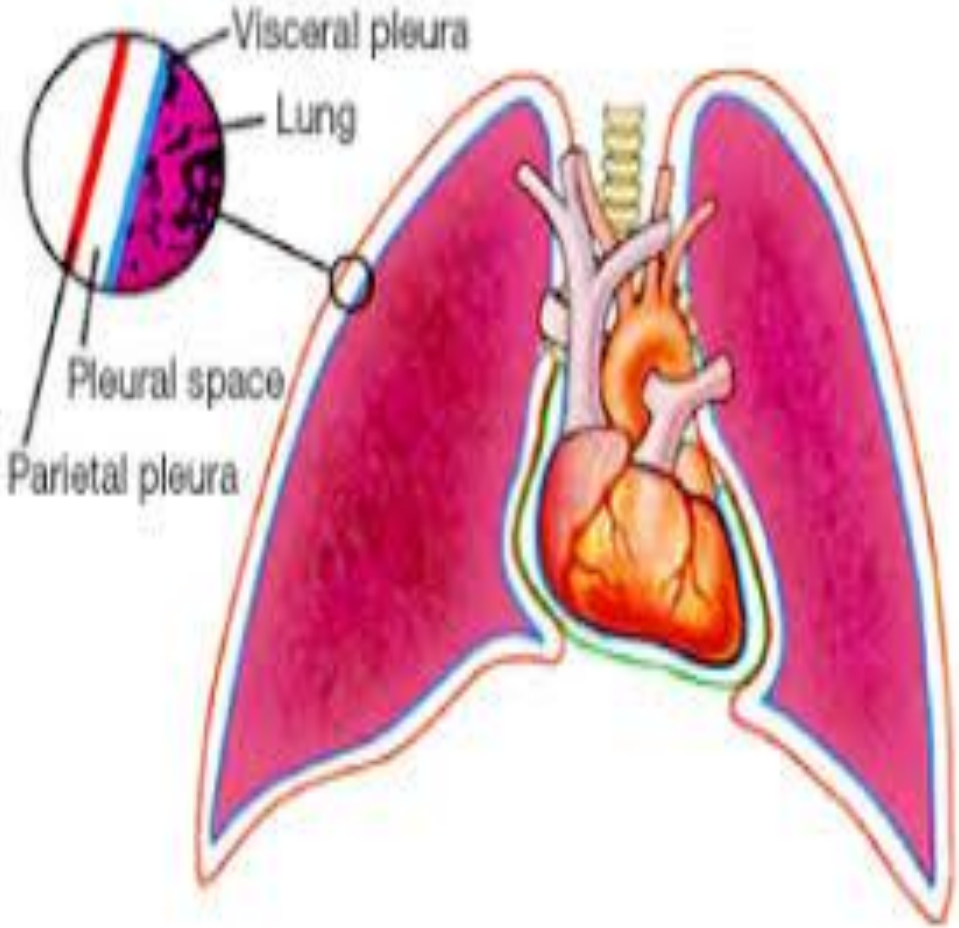
3- Lateral plate mesoderm

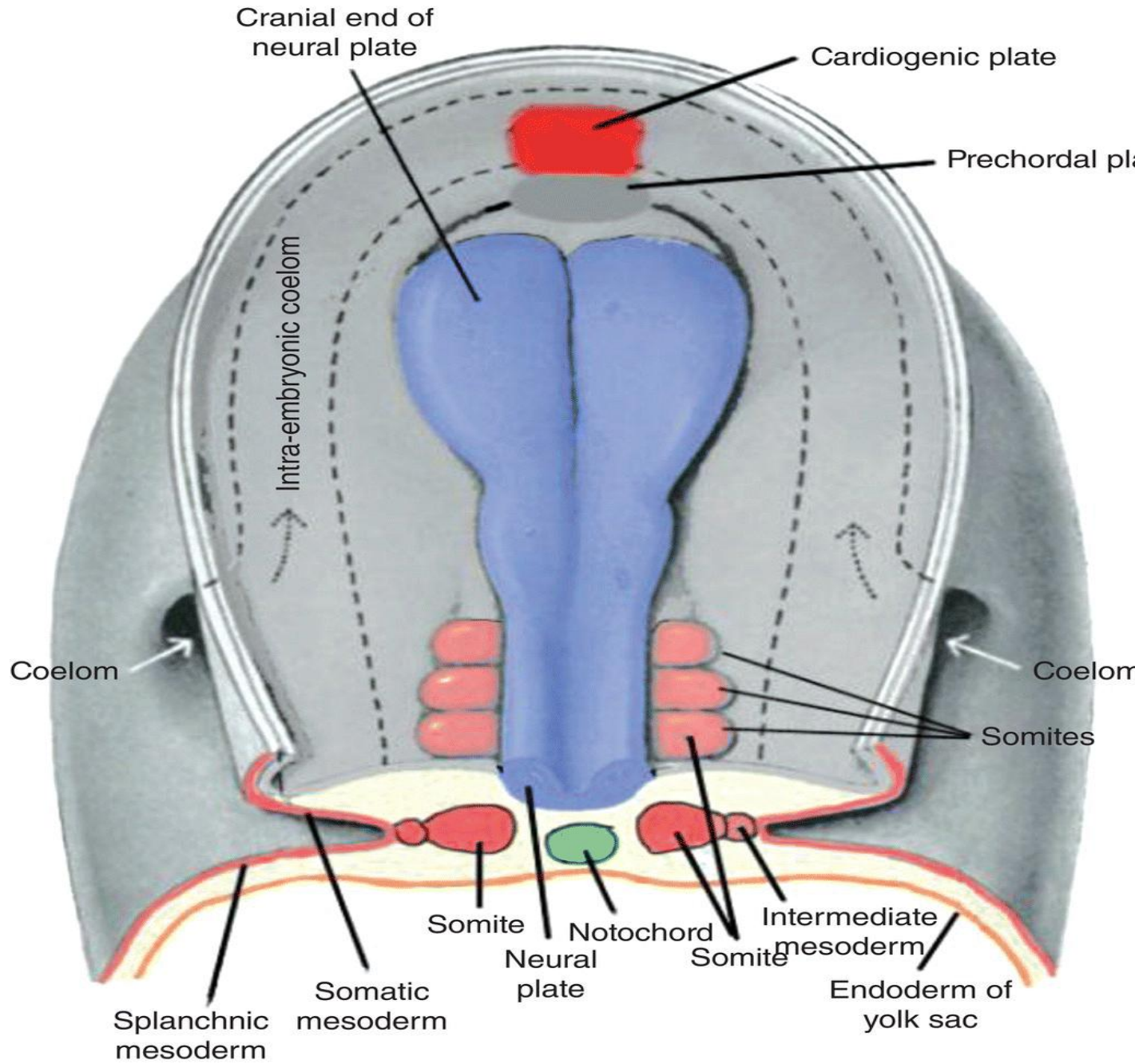
1- Mesoderm from the parietal layer (somatopleuric mesoderm), together with overlying ectoderm, forms the **lateral body wall folds** .These folds, together with the head (cephalic) and tail (caudal) folds, **close the ventral body wall**.

2-The parietal layer of lateral plate mesoderm then **forms the dermis of the skin in the body wall and limbs, the bones and connective tissue of the limbs, and the sternum.** In addition, **sclerotome and myotomes** that migrate into the parietal layer of lateral plate mesoderm form **the costal cartilages, ribs, limb muscles, and most of the body wall muscles. Also, the parietal mesoderm forms the parietal layer of body cavities (pericardium, pleura and peritoneum).**

2- Visceral layer of lateral mesoderm, with embryonic endoderm, forms the **wall of the gut tube. They also, forms the visceral layer of body cavities.**




Visceral pleura
Lung
Pleural space
Parietal pleura


Cranial end of neural plate
Cardiogenic plate
Prechordal plate
Intra-embryonic coelom
Coelom
Coelom
Somites
Somite
Notochord
Somite
Intermediate mesoderm
Neural plate
Somatic mesoderm
Splanchnic mesoderm
Endoderm of yolk sac

Folding of the embryo

It is a significant event in **the establishment of body form into a somewhat cylindrical embryo.**

Cause of folding (*for reading):*

Folding occurs in both the **median and horizontal planes** and results from rapid growth of the embryo. The growth rate at the sides of the embryonic disc fails to keep pace with the rate of growth in the long axis as the embryo increases rapidly in length.

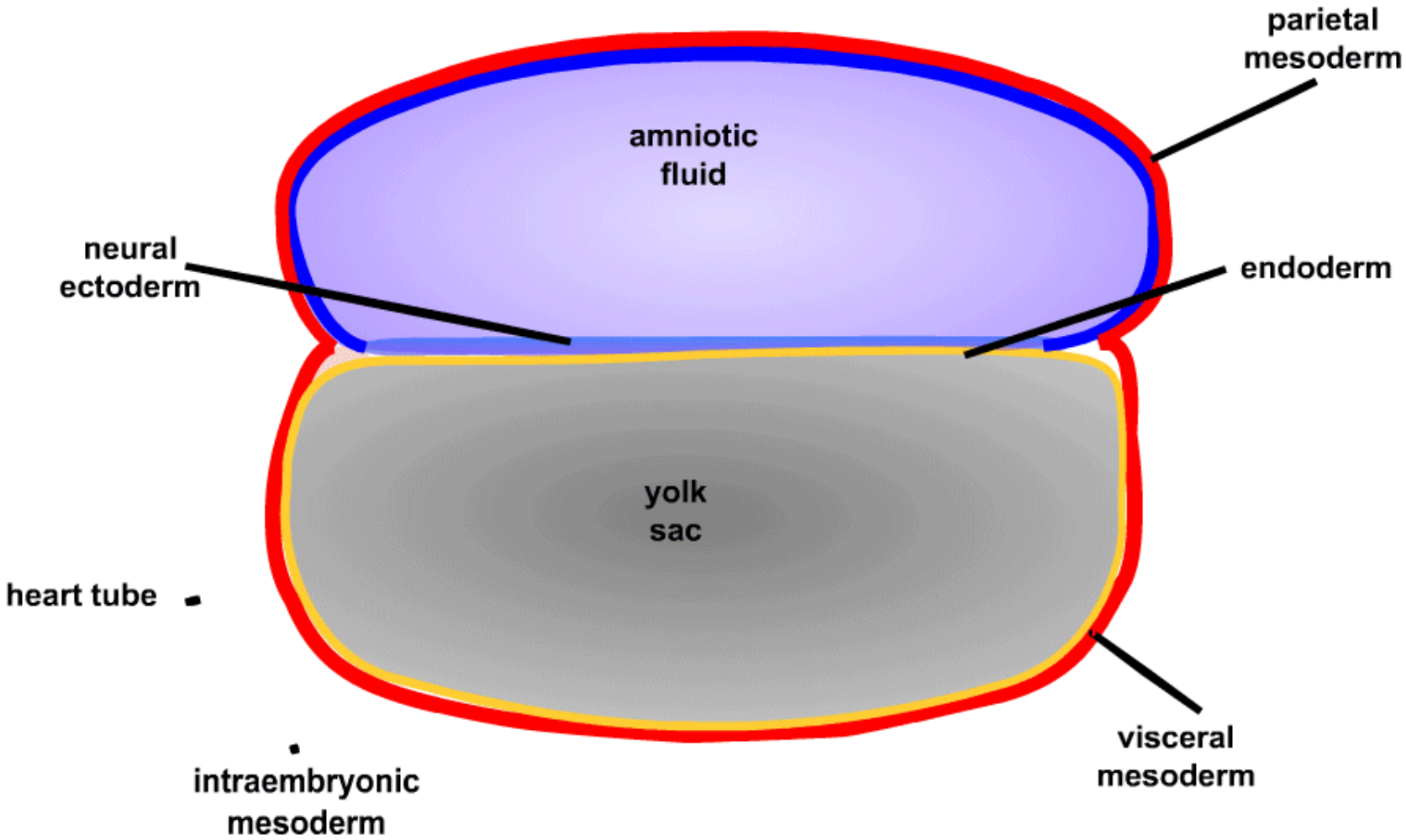
Folding of the Embryo in the Median Plane

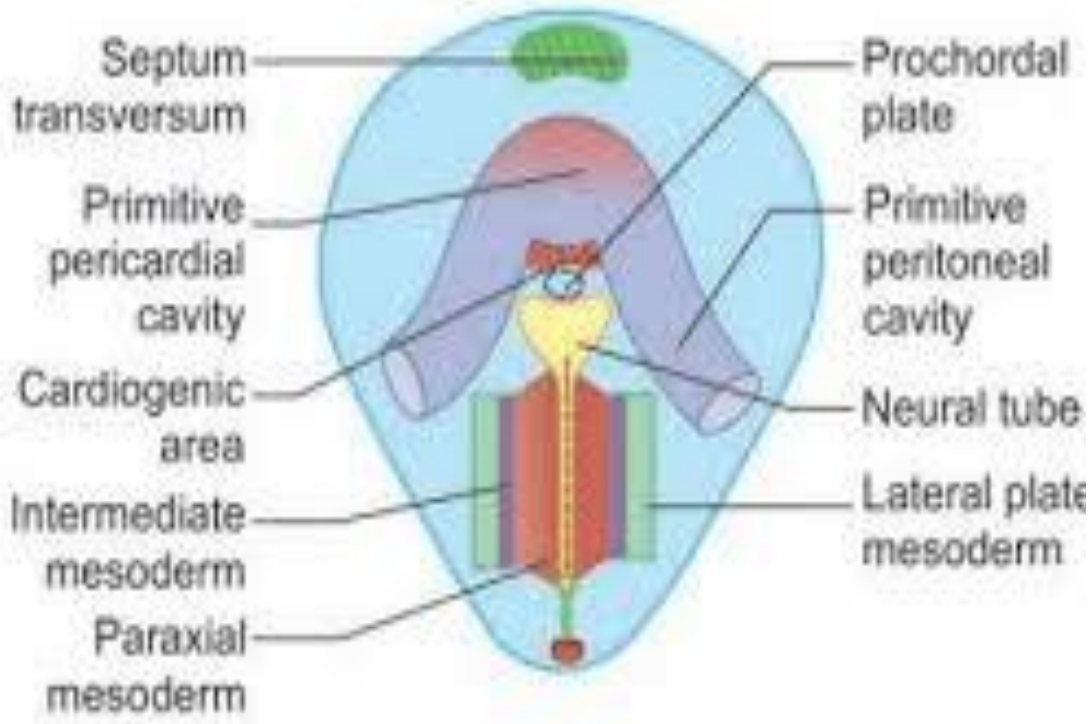
Folding of the ends of the embryo ventrally produces head and tail folds that result in the cranial and caudal regions moving ventrally as the embryo elongates cranially and caudally.

1-Head Fold

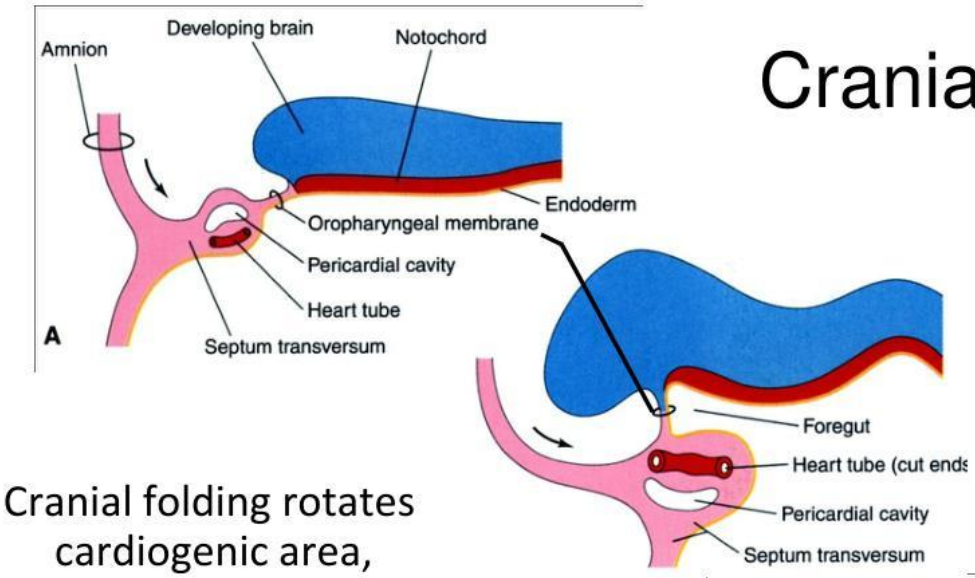
-By the **beginning of the fourth week**, the **developing forebrain grows and overhangs the developing heart**.

-Concomitantly, the **septum transversum** (transverse septum), **primordial heart, pericardial coelom(cavity), and oropharyngeal membrane move onto the ventral surface** of the embryo. During folding, part of the endoderm of the yolk sac is incorporated into the embryo as the **foregut**.


parietal
mesoderm
amniotic
fluid
neural
ectoderm
endoderm
yolk
sac
heart tube
visceral
mesoderm
intraembryonic
mesoderm

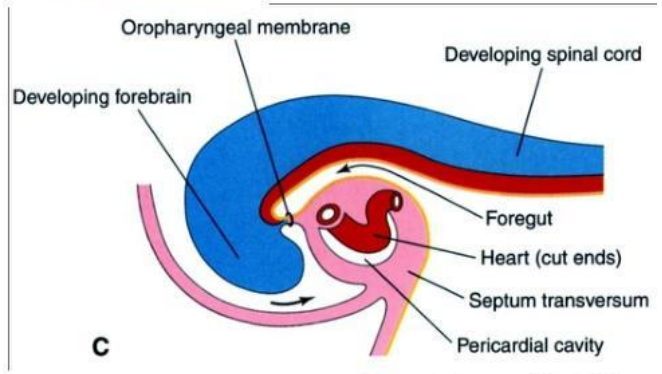


Cranial folding



Cranial folding rotates cardiogenic area,

moves it ventrally and caudally, and orients **heart tube** and **pericardial cavity**



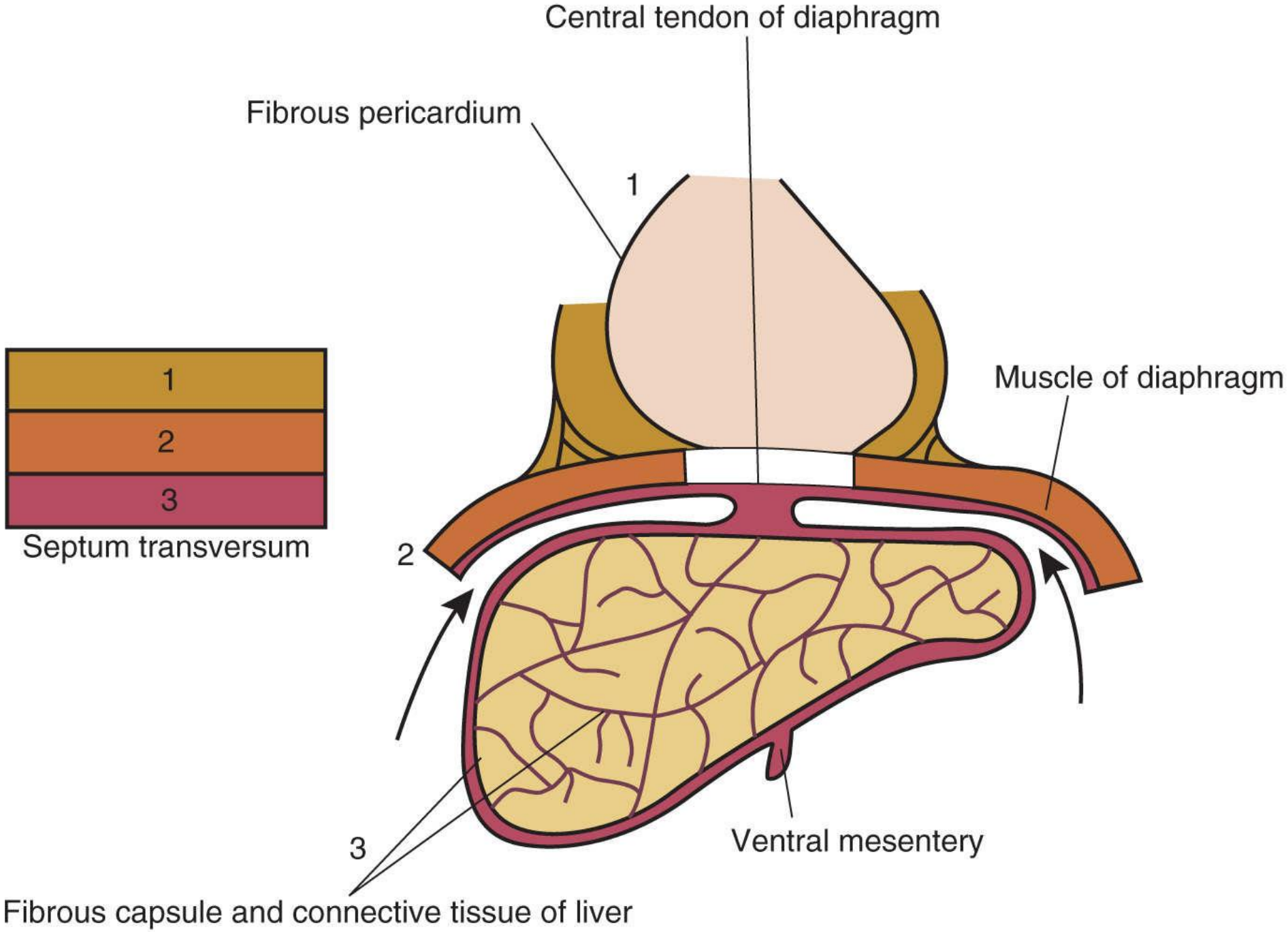
Moore & Persaud fig 13-9

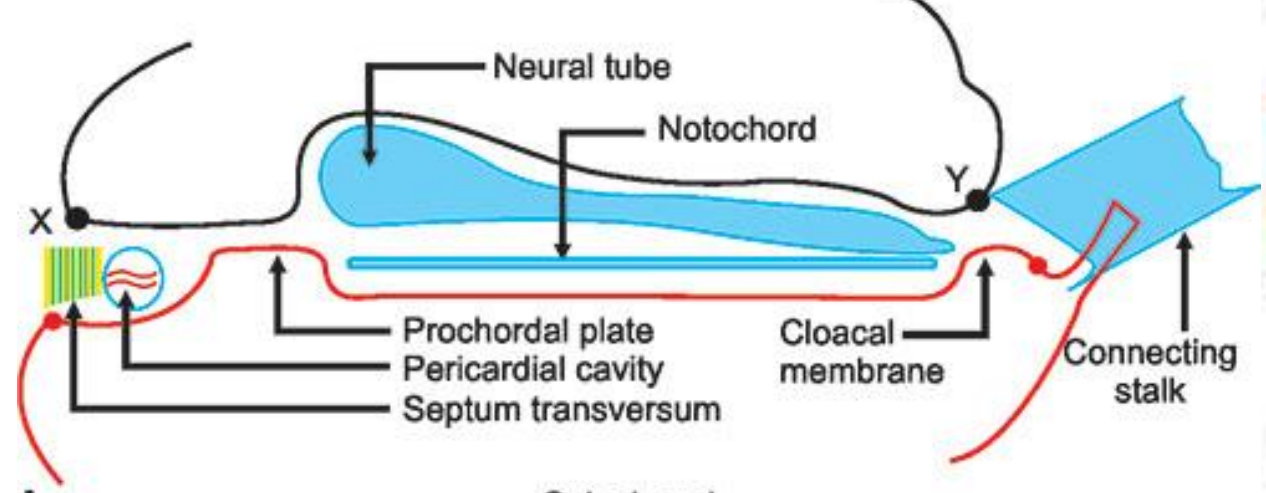
-After folding, **the septum transversum lies caudal to the heart** where it develops into **the central tendon of the diaphragm** .

Tail fold:

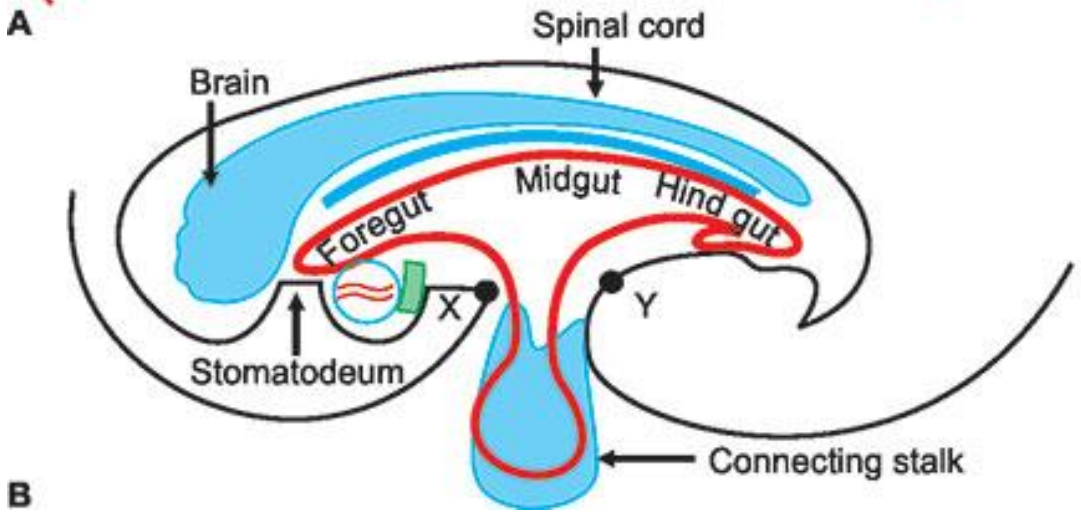
-Folding of the caudal end of the embryo results primarily from growth of the distal part of the neural tube. During folding, part of the endodermal germ layer is incorporated into the embryo as the **hindgut** (primordium of descending colon).

-**The terminal part of the hindgut soon dilates** slightly to form the **cloaca** (primordium of urinary bladder and rectum). The **connecting stalk** (primordium of umbilical cord) is now attached to the ventral surface of the embryo.

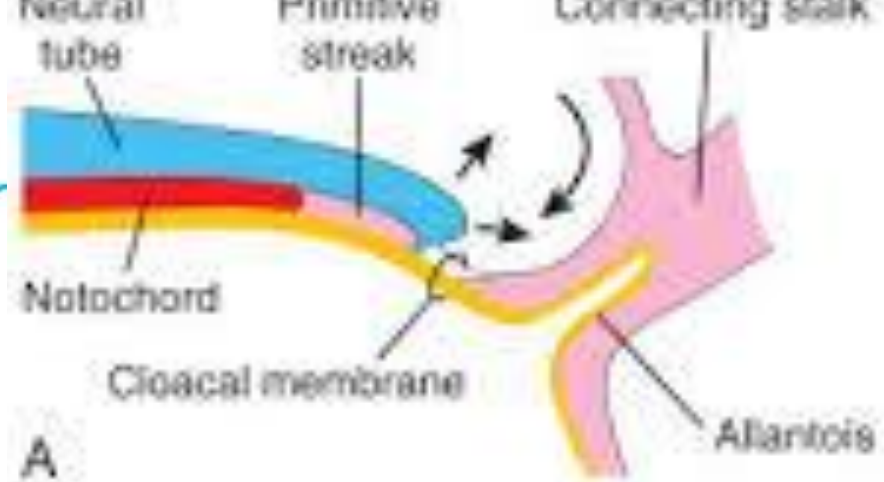

Central tendon of diaphragm
Fibrous pericardium
1
Muscle of diaphragm
1
2
3
Septum transversum
2
3
Ventral mesentery
Fibrous capsule and connective tissue of liver


Neural tube
Notochord
X
Y
Prochordal plate
Pericardial cavity
Septum transversum
Cloacal membrane
Connecting stalk

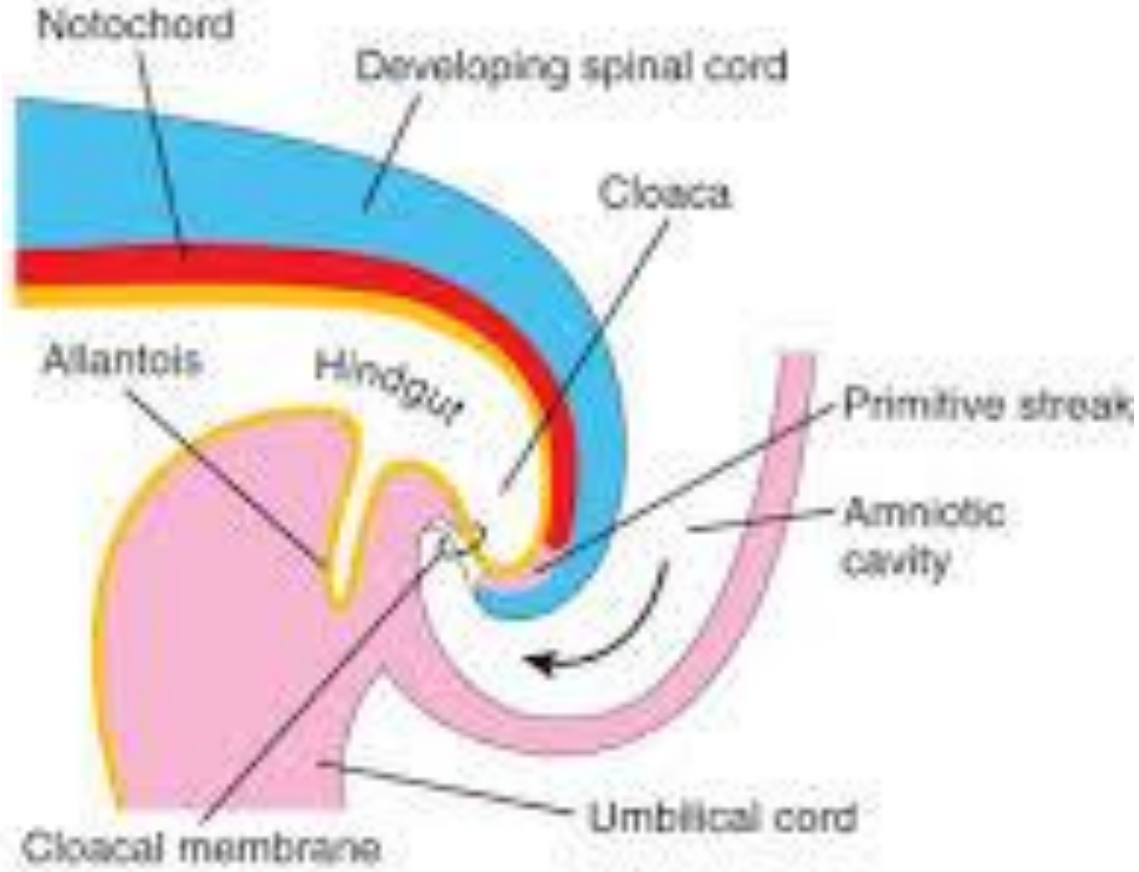
A


Spinal cord
Brain
Midgut
Hind gut
Foregut
X
Y
Stomatodeum
Connecting stalk

B


tube
streak
Connecting stalk
Notochord
Cloacal membrane
Allantois

A


Notochord
Developing spinal cord
Cloaca
Allantois
Hindgut
Primitive streak
Amniotic cavity
Umbilical cord
Cloacal membrane

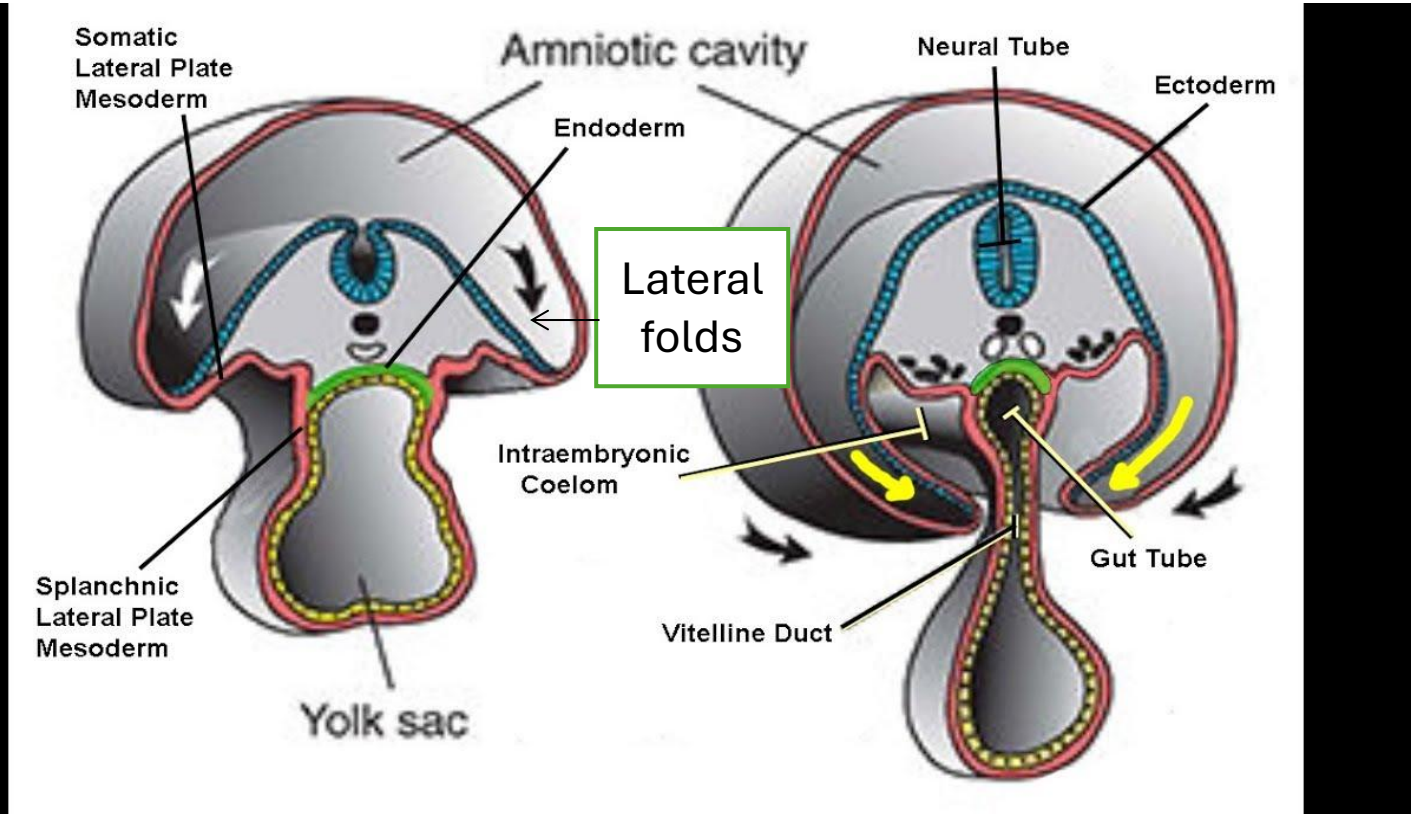
Folding of the Embryo in the Horizontal Plane

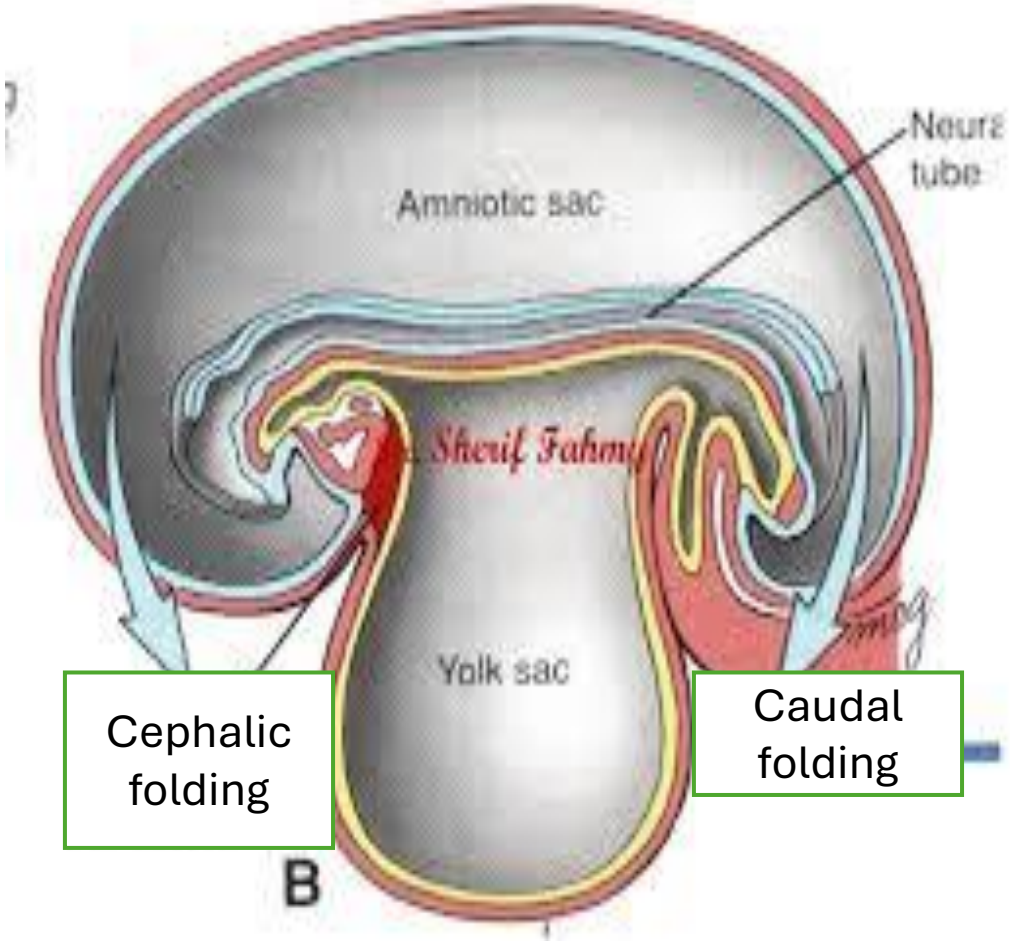
-Folding of the sides of the embryo produces right and left **lateral folds** .

–Lateral folding is produced by the rapidly growing spinal cord and somite.

The **ventrolateral wall fold toward the median plane, rolling the edges of the embryonic disc ventrally and forming a roughly cylindrical embryo**.

As the abdominal walls form, part of the endoderm germ layer is incorporated into the embryo as the **midgut** (primordium of small intestine).

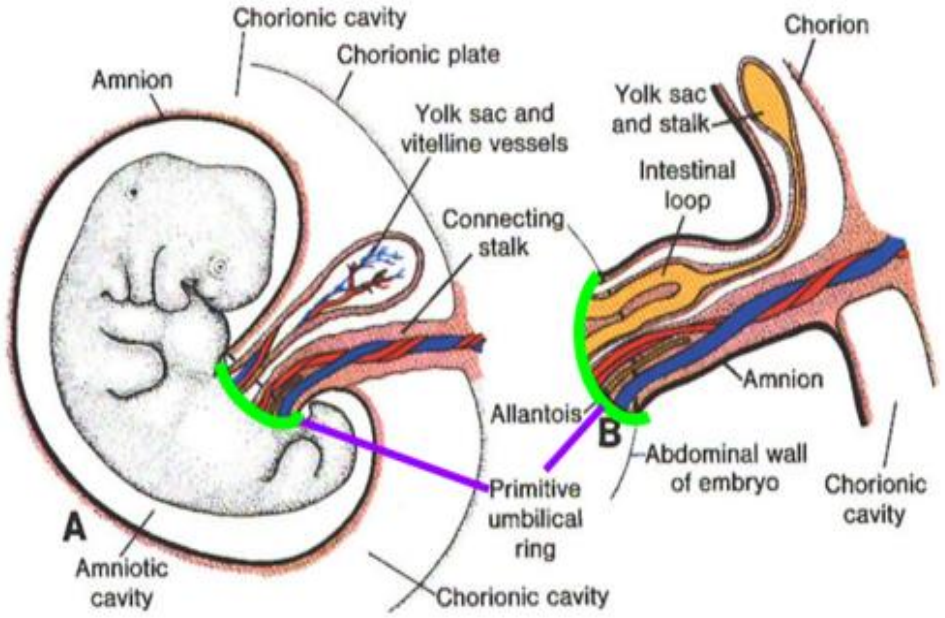

Somatic
Lateral Plate
Mesoderm
Amniotic cavity
Endoderm
Neural Tube
Ectoderm
Lateral
folds
Intraembryonic
Coelom
Gut Tube
Splanchnic
Lateral Plate
Mesoderm
Vitelline Duct
Yolk sac

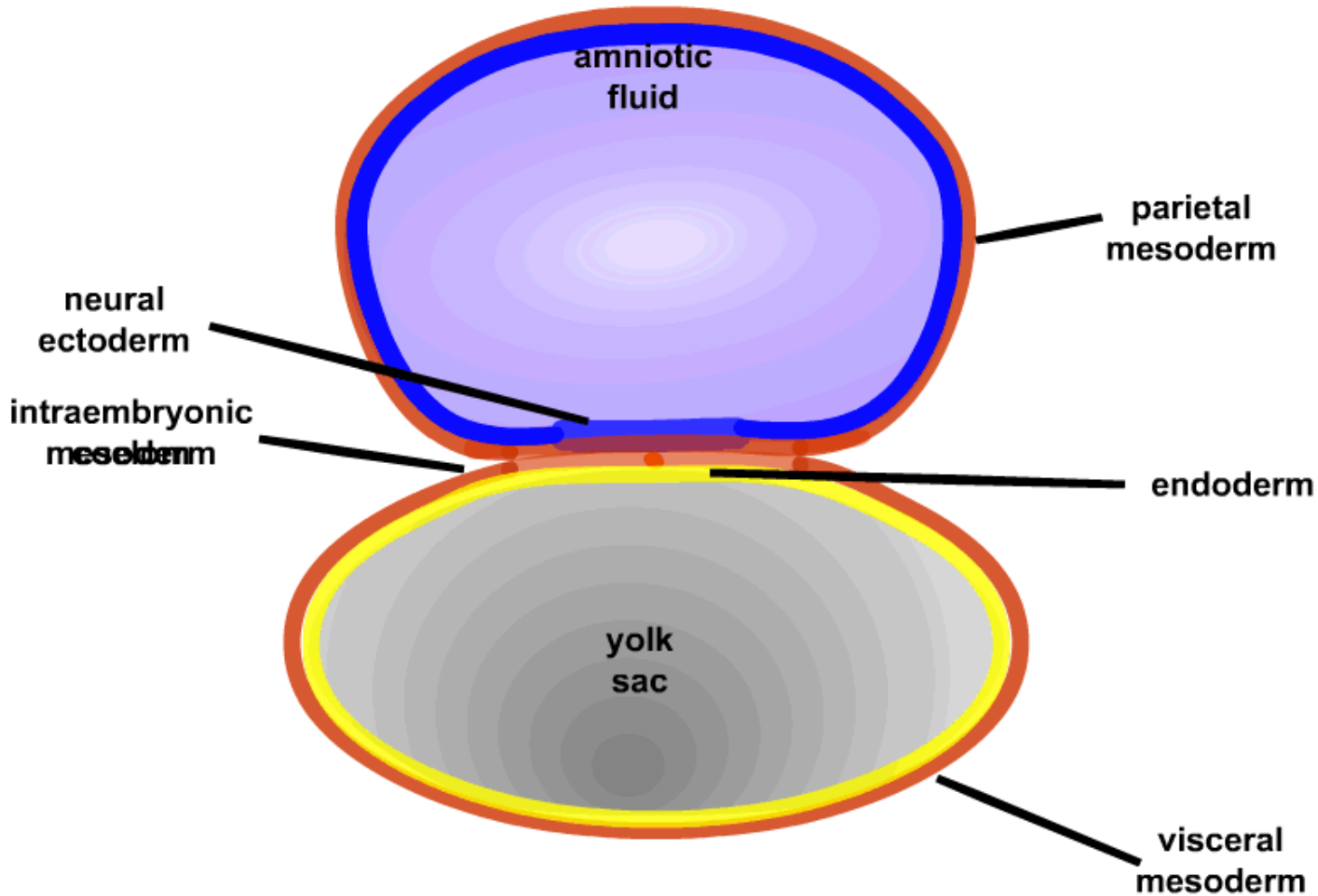

Amniotic sac
Yolk sac
Cephalic
folding
Caudal
folding
B

-After lateral folding, the connection between midgut and yolk sac called **omphaloenteric(yolk sac) duct**.

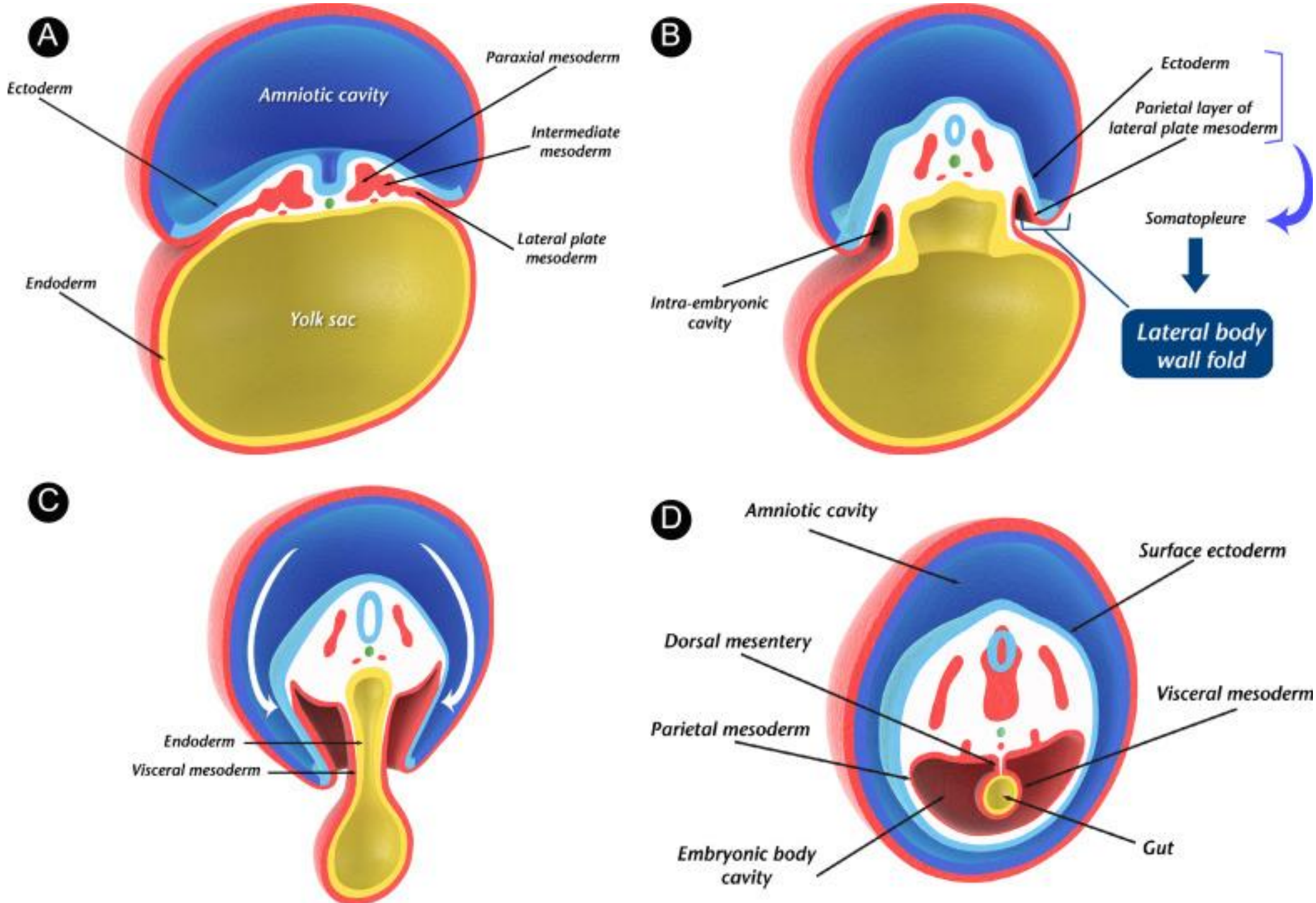
-The head and tail and two lateral folds move ventrally, **pulling the amnion down with them, such that the embryo lies within the amniotic cavity. The** ventral body wall closes completely except for the umbilical region where the connecting stalk and yolk sac duct remain attached .

- The region of attachment of the amnion to the ventral surface of the embryo is **narrow umbilical region** .




amniotic
fluid
parietal
mesoderm
neural
ectoderm
intraembryonic
endoderm
yolk
sac
visceral
mesoderm

Day 17


A
Ectoderm
Amniotic cavity
Paraxial mesoderm
Intermediate mesoderm
Lateral plate mesoderm
Endoderm
Yolk sac
B
Ectoderm
Parietal layer of lateral plate mesoderm
Somatopleure
Intra-embryonic cavity
Lateral body wall fold
C
Endoderm
Visceral mesoderm
D
Amniotic cavity
Surface ectoderm
Dorsal mesentery
Visceral mesoderm
Parietal mesoderm
Gut
Embryonic body cavity

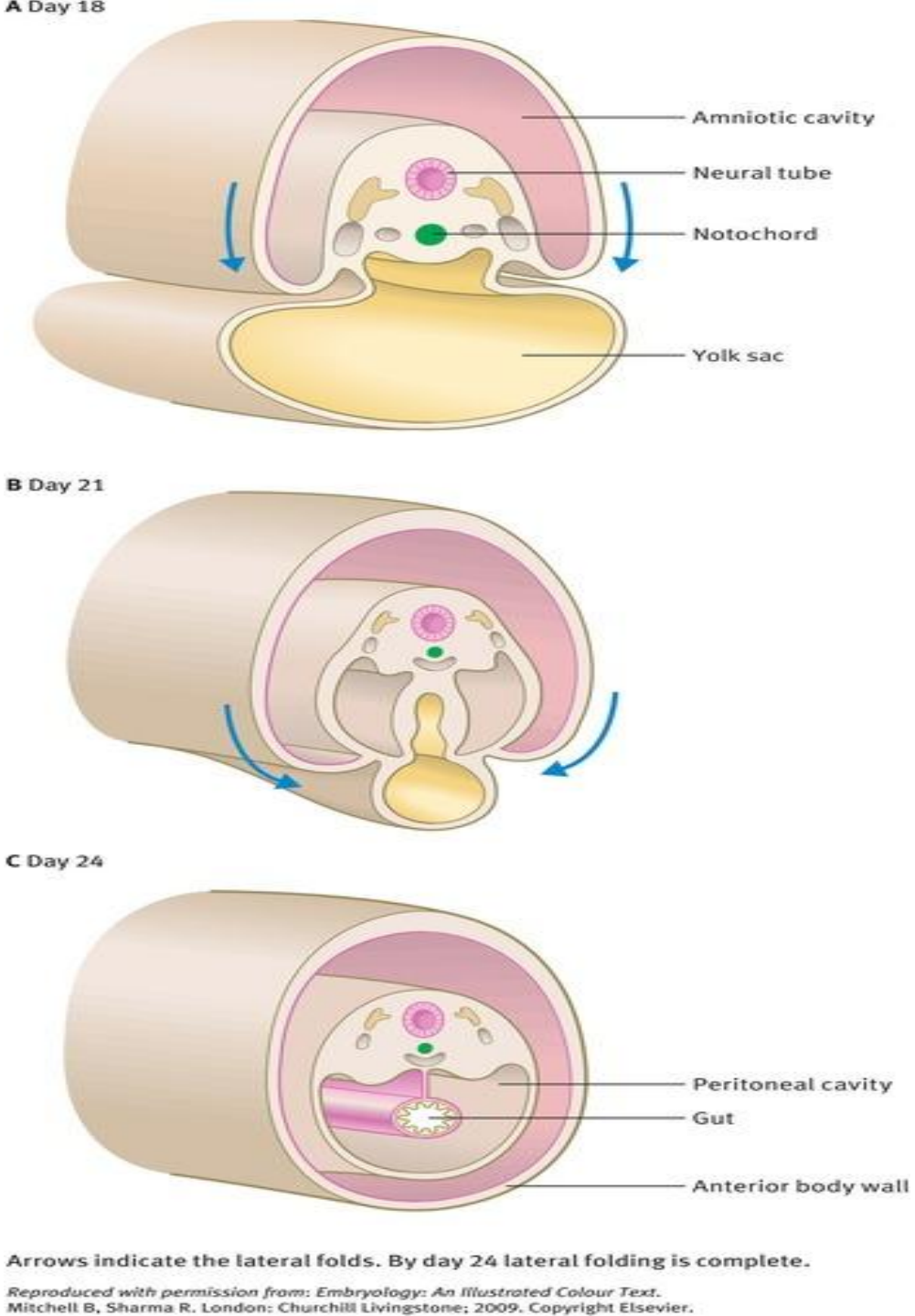
What is the results of folding?

1- formation of gut (foregut , mid gut and hind gut) with formation of yolk sac duct.

2-Migration of heart, pericardial cavity and oropharyngeal membrane ventrally instead of cranially.

3-Migration of septum transversum caudal to heart.

4-Closure of ventral body wall except at region of umbilical ring

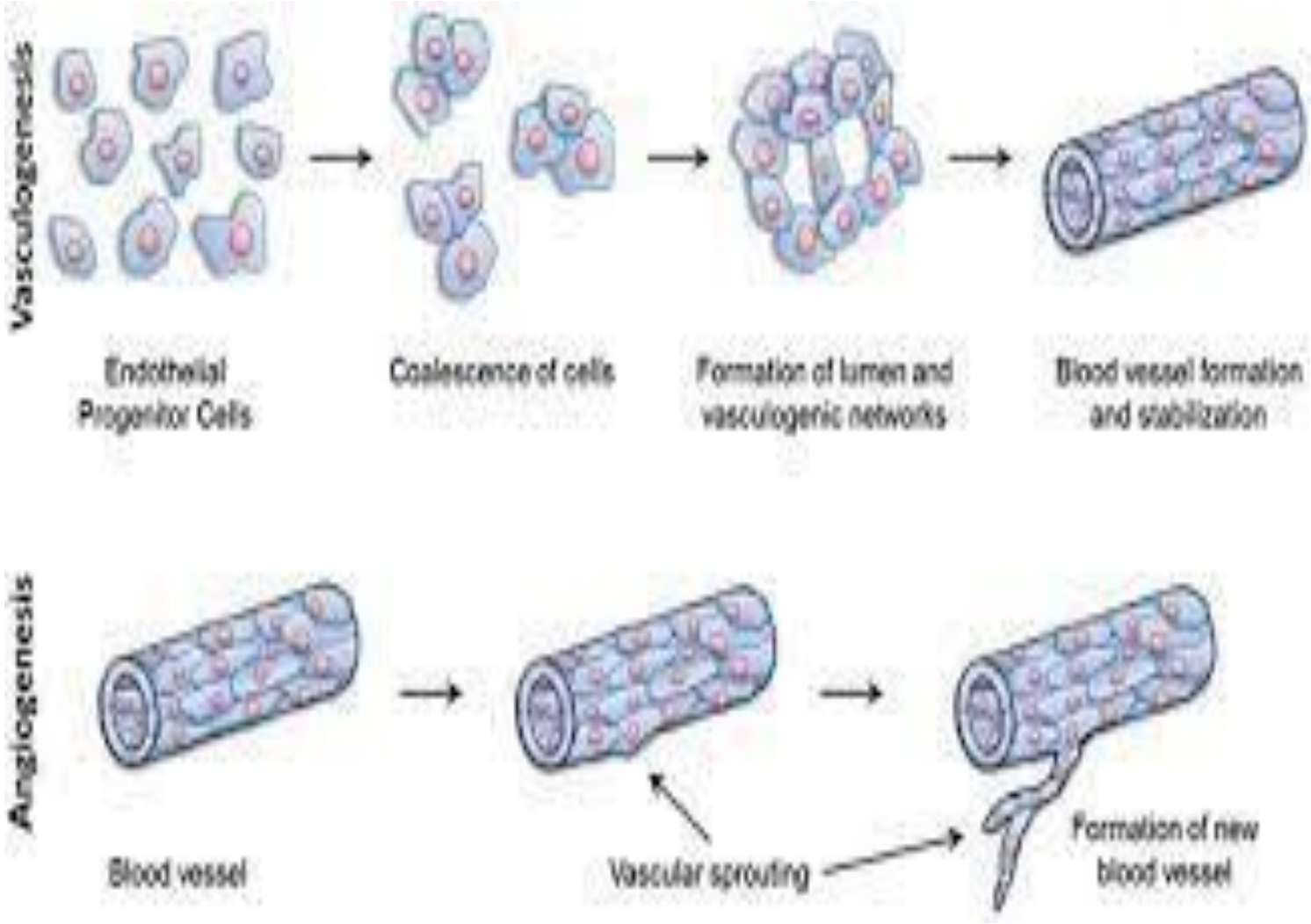


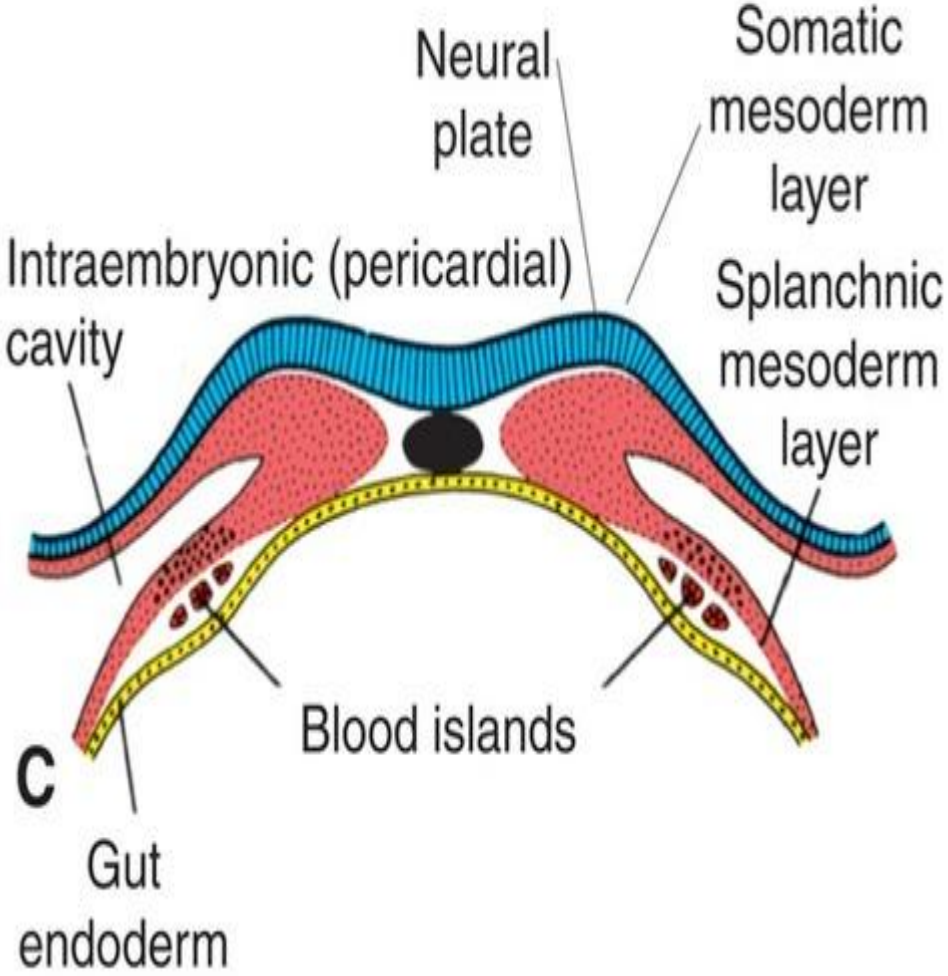
Arrows indicate the lateral folds. By day 24 lateral folding is complete.

Blood and blood vessel formation

(A) Blood vessels form in two ways: **vasculogenesis,** whereby vessels arise from blood islands and **angiogenesis,** in which vessels sprout from existing vessels.

(B) The first blood islands appear in **mesoderm surrounding the wall of the yolk sac at 3 weeks of development and slightly later in lateral plate mesoderm and other regions .**These islands arise from mesoderm cells that are induced to form hemangioblasts, a common precursor for vessel and blood cell formation.

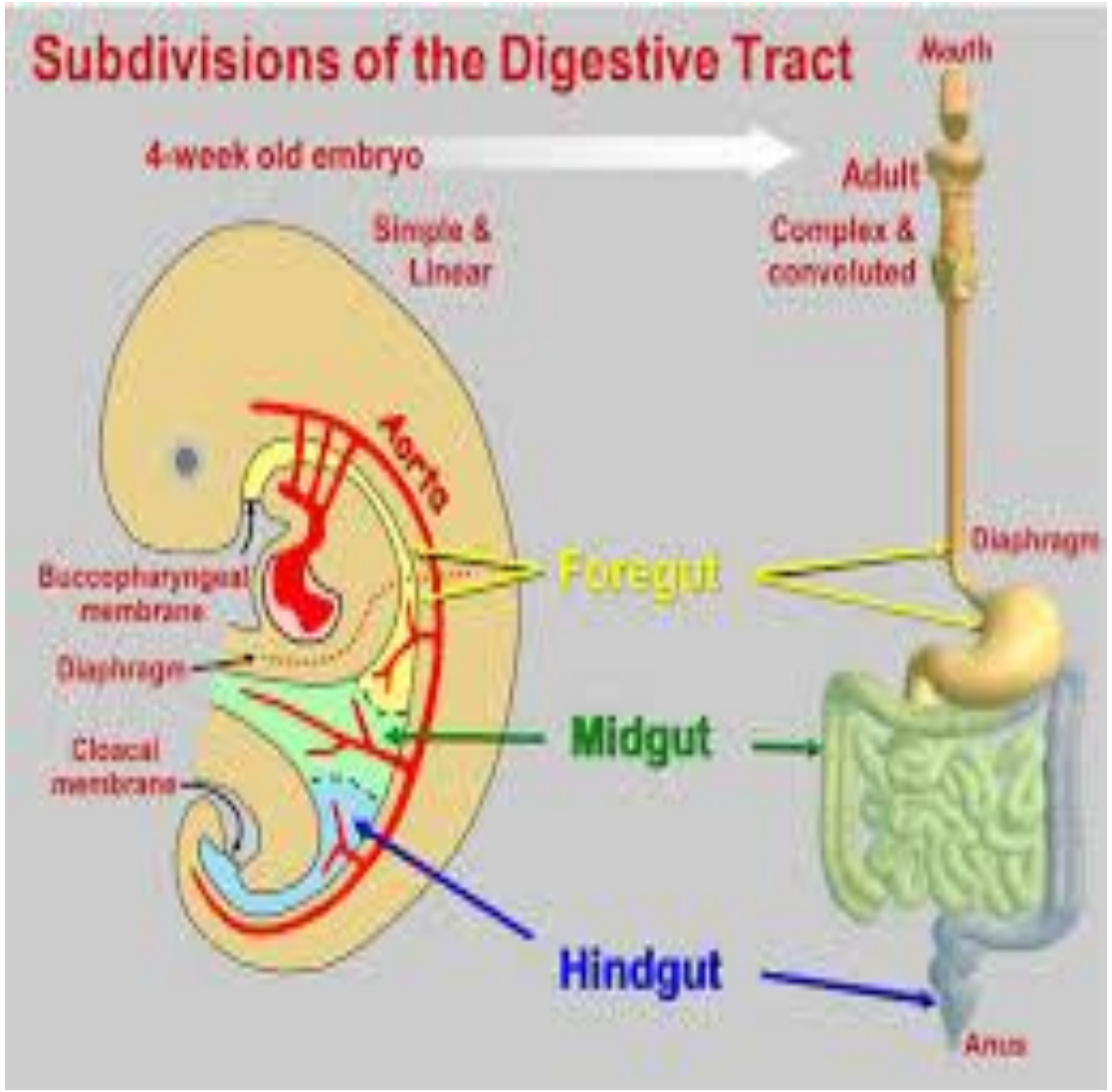


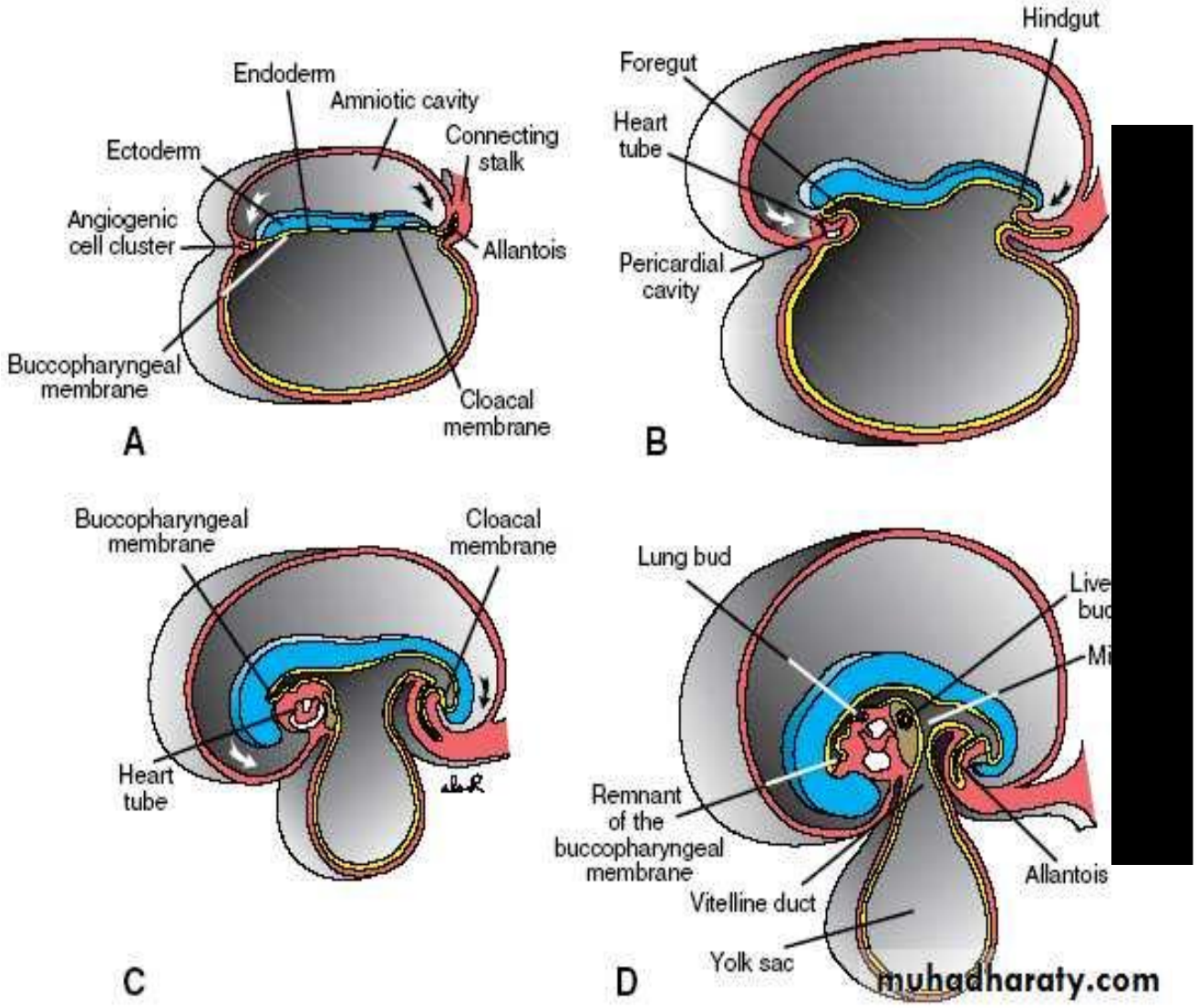


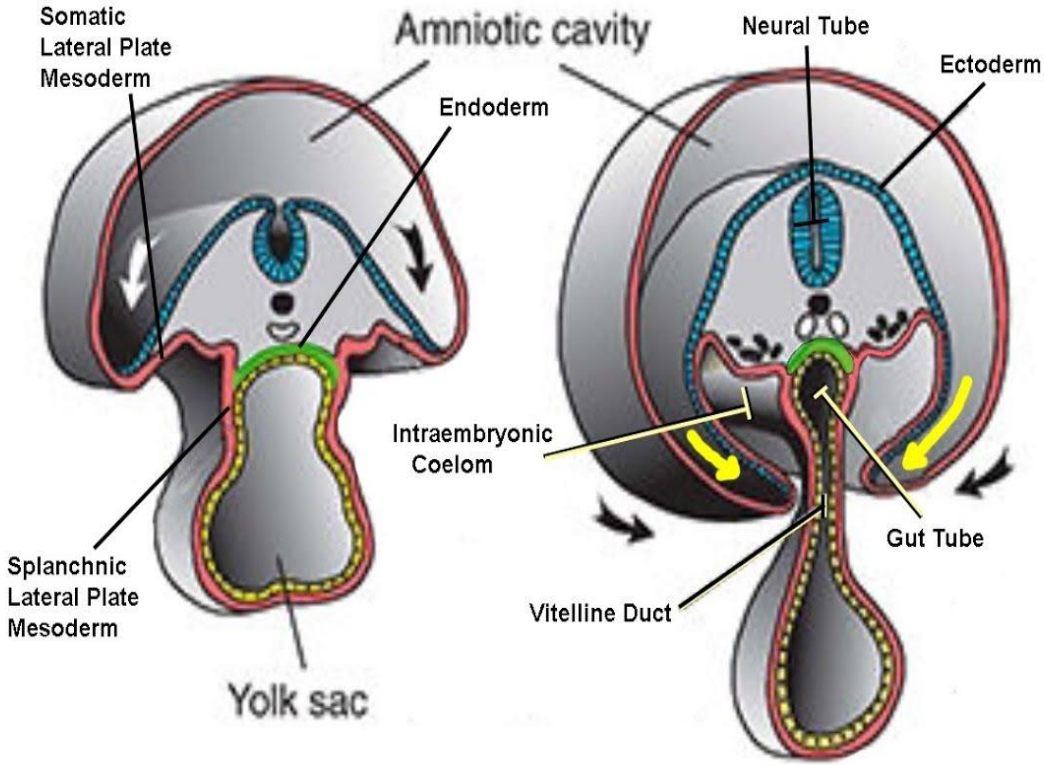
5-1C Heart development: Blood islands

Derivatives of the endodermal germ layer (formation of gut tube)

1-The gastrointestinal tract is the main organ system derived from the endodermal germ layer. This germ layer covers the ventral surface of the embryo and forms the roof of the yolk sac .

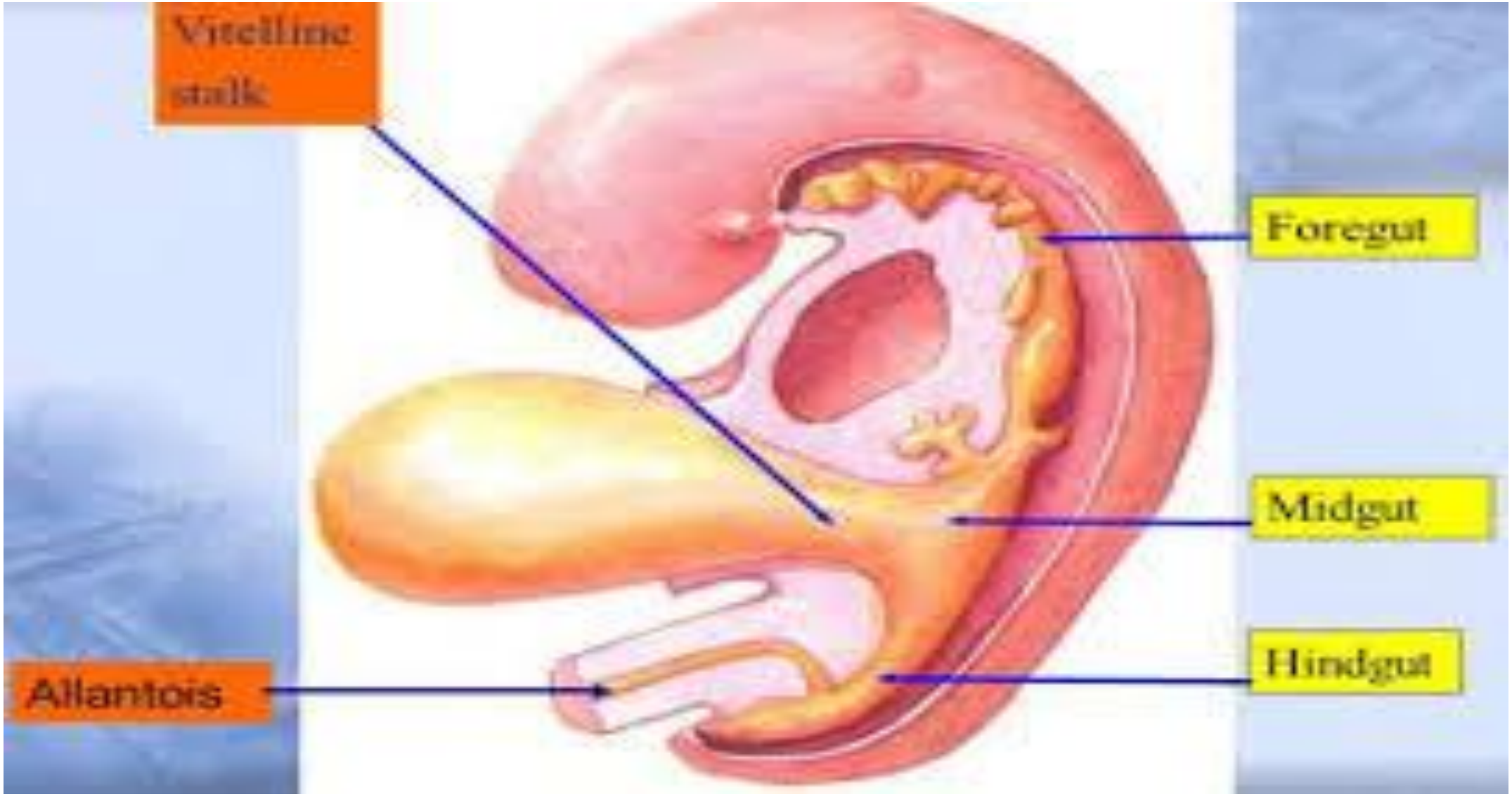



Endoderm
Amniotic cavity
Connecting stalk
Ectoderm
Angiogenic cell cluster
Allantois
Buccopharyngeal membrane
Cloacal membrane
A
Hindgut
Foregut
Heart tube
Pericardial cavity
B
Buccopharyngeal membrane
Cloacal membrane
Heart tube
C
Lung bud
Remnant of the buccopharyngeal membrane
Vitelline duct
Allantois
Yolk sac
D
muhadharaty.com


Somatic Lateral Plate Mesoderm
Amniotic cavity
Neural Tube
Ectoderm
Endoderm
Intraembryonic Coelom
Gut Tube
Splanchnic Lateral Plate Mesoderm
Vitelline Duct
Yolk sac

2- As a result of cephalocaudal growth and closure of the lateral body wall folds , a larger portion of the endodermal germ layer is incorporated into the body of the embryo to form the **gut tube**.

5-The tube is divided into three regions: **the foregut, midgut, and hindgut**. The midgut communicates with the yolk sac by way of a broad stalk, the **vitelline (yolk sac) duct** . This duct is wide initially, but with further growth of the embryo, it becomes narrow and much longer.


Vitelline stalk
Foregut
Midgut
Hindgut
Allantois

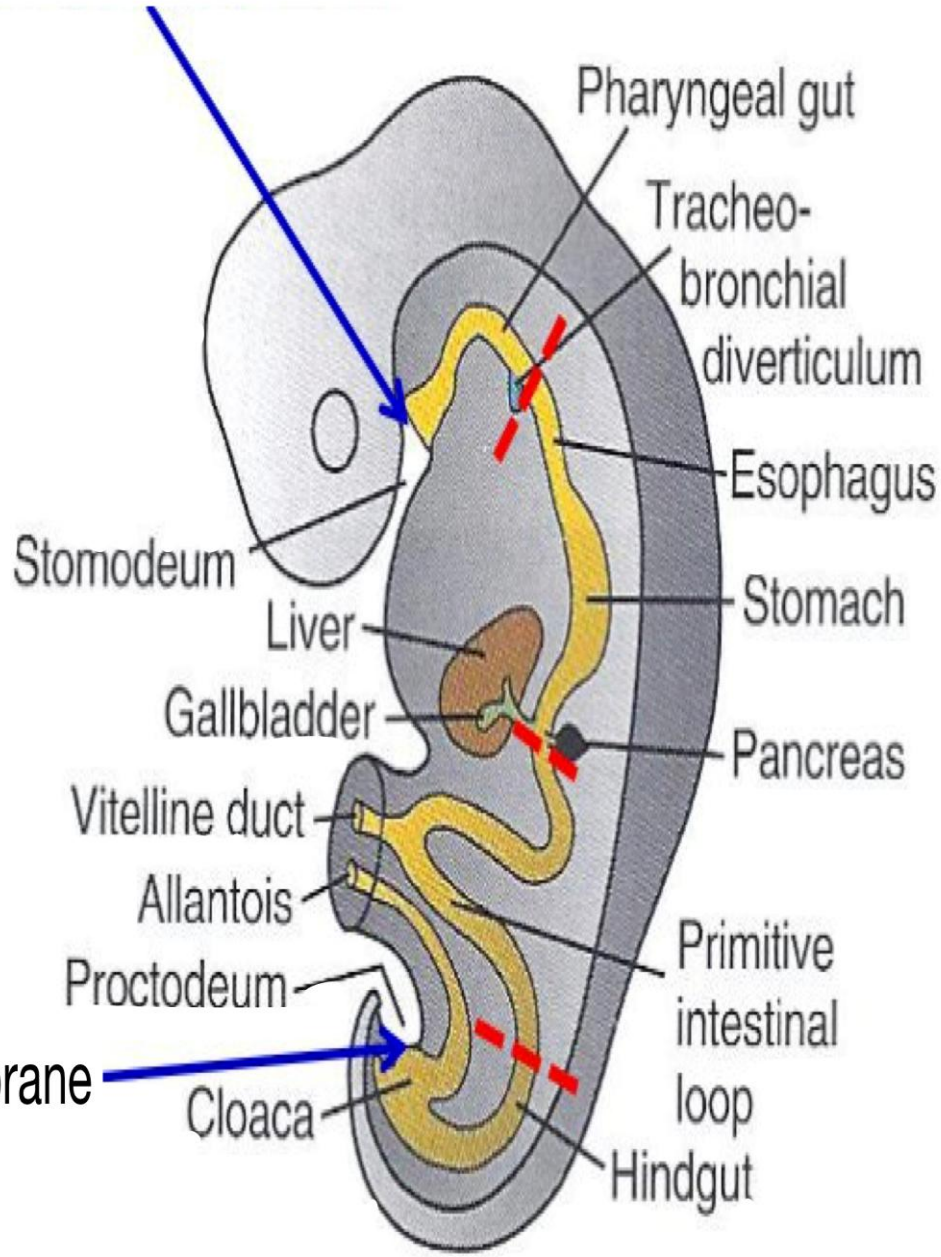
6- At the cephalic end of the gut , the foregut is temporarily bounded by an ectodermal–endodermal membrane called the **oropharyngeal membrane**. This membrane separates the **stomadeum, the primitive oral cavity derived from ectoderm, from the pharynx which is a part of the foregut derived from endoderm**.

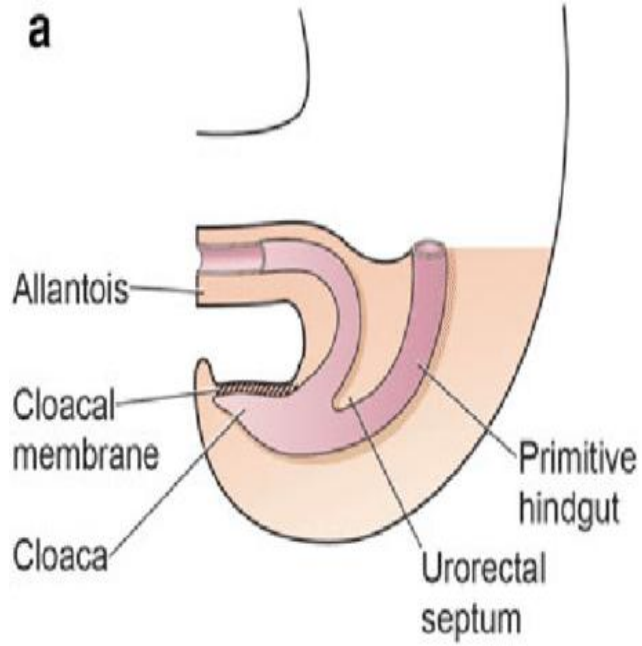
7-In the fourth week, the **oropharngeal membrane ruptures**, establishing an open connection between the oral cavity and the primitive gut.

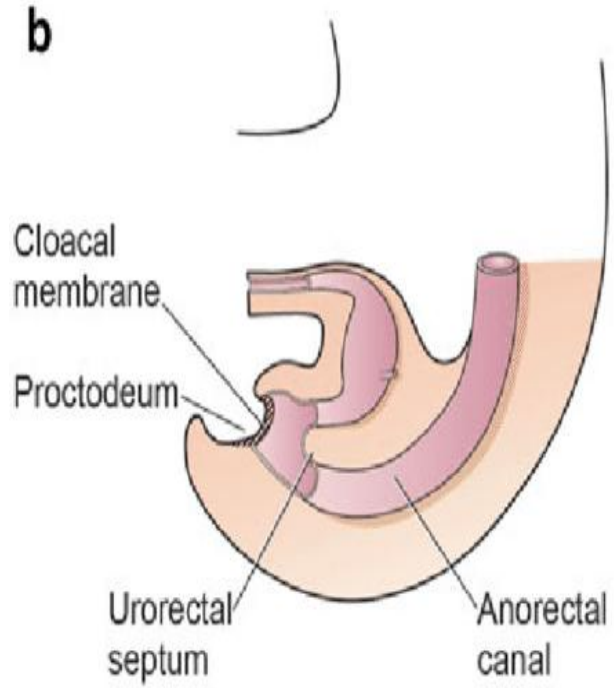
8- The hindgut also terminates temporarily at an ectodermal– endodermal membrane, **the cloacal membrane**. This membrane separates the upper part of the anal canal, derived from endoderm, from the lower part, called the **proctodeum, which is formed by an invaginating pit lined by ectoderm.**

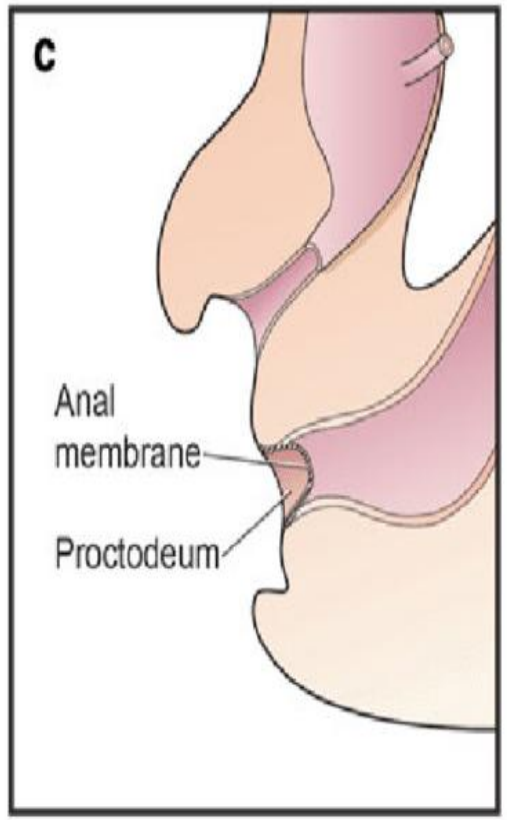
9- The cloacal membrane breaks down in **the seventh week** to create the opening for the anus. As result of cephalocaudal growth and lateral folding, the allantois is incorporated into the body of the embryo forming **the cloaca**.

Buccopharyngeal Membrane







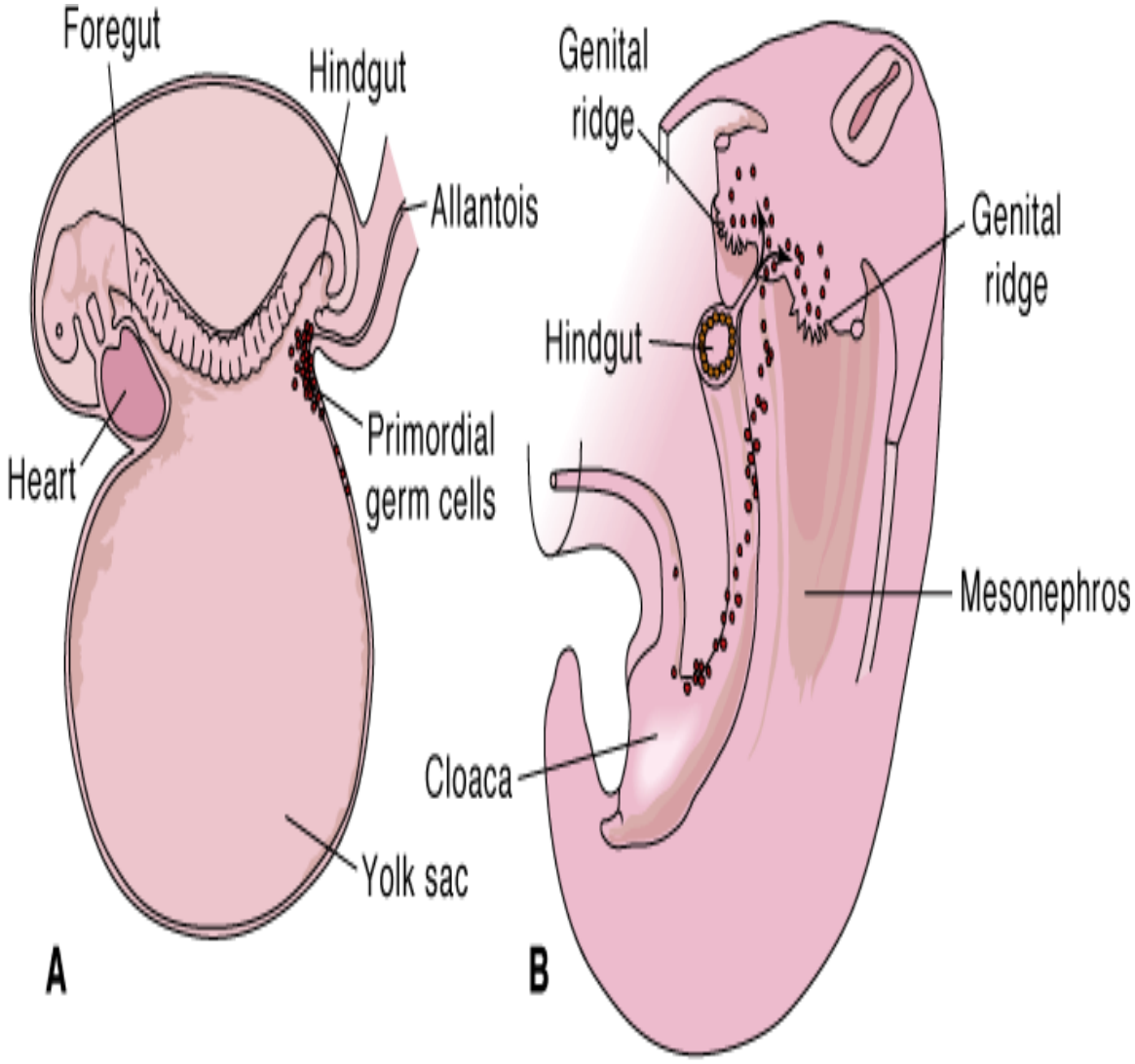


Function of yolk sac:

(a) It act as a nutritive organ during the earliest stages of development

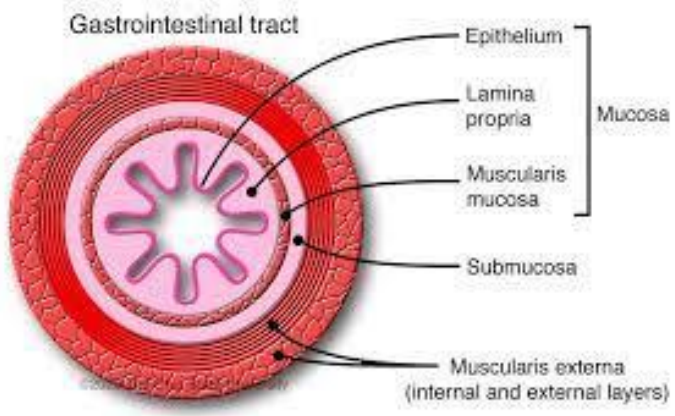
(b) It also contributes some of the first blood cells, although this role is very transitory.

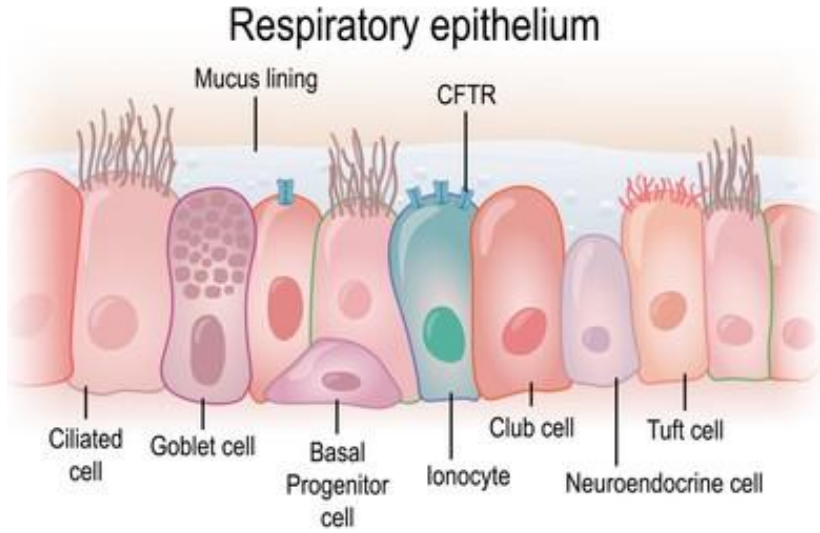
(c) One of its main functions is to provide germ cells that reside in its posterior wall and later migrate to the gonads to form eggs and sperm

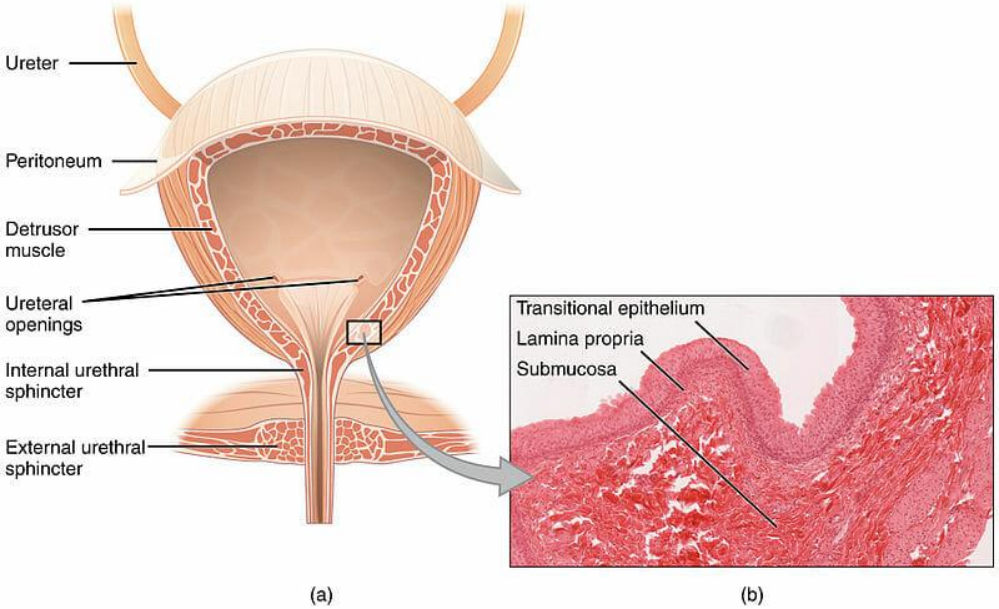


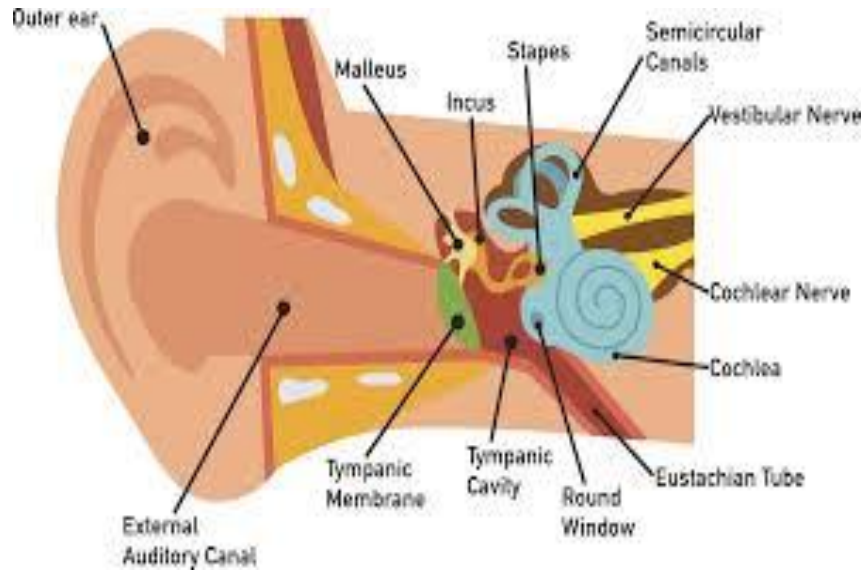
Summary of endodermal derivatives:

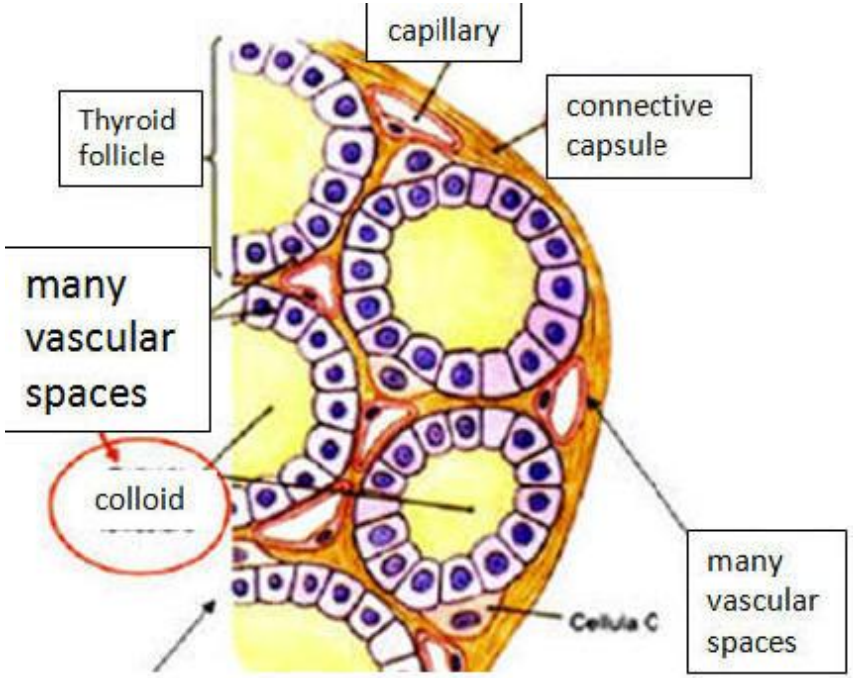
- The epithelial lining of the gastrointestinal tract except for an upper and lower part derived from ectoderm.
- The epithelial lining of respiratory tract.
- The parenchyma of the thyroid, parathyroids, liver, and pancreas.
- The reticular stroma of the tonsils and the thymus.
- The epithelial lining of the urinary bladder and the urethra .
- The epithelial lining of the tympanic cavity and auditory tube.


Gastrointestinal tract
Epithelium
Lamina propria
Muscularis mucosa
Mucosa
Submucosa
Muscularis externa
(internal and external layers)

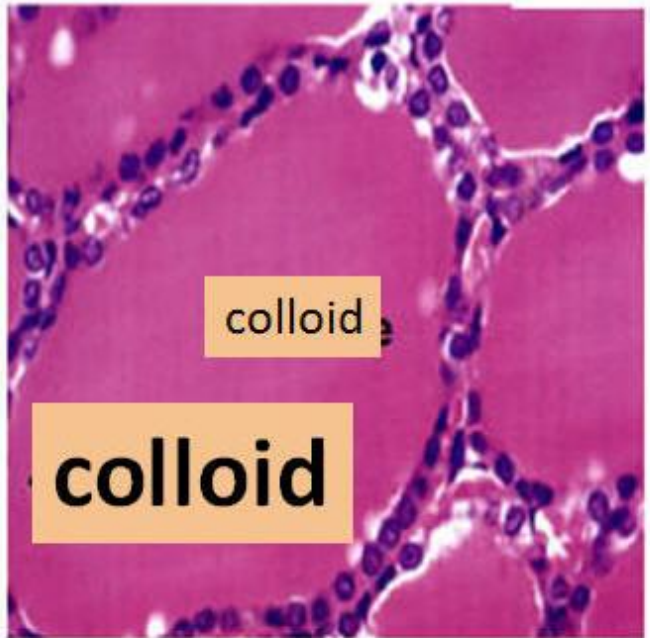

Respiratory epithelium
Mucus lining
CFTR
Ciliated cell
Goblet cell
Basal Progenitor cell
Ionocyte
Club cell
Tuft cell
Neuroendocrine cell
shutterstock.com · 1538801927

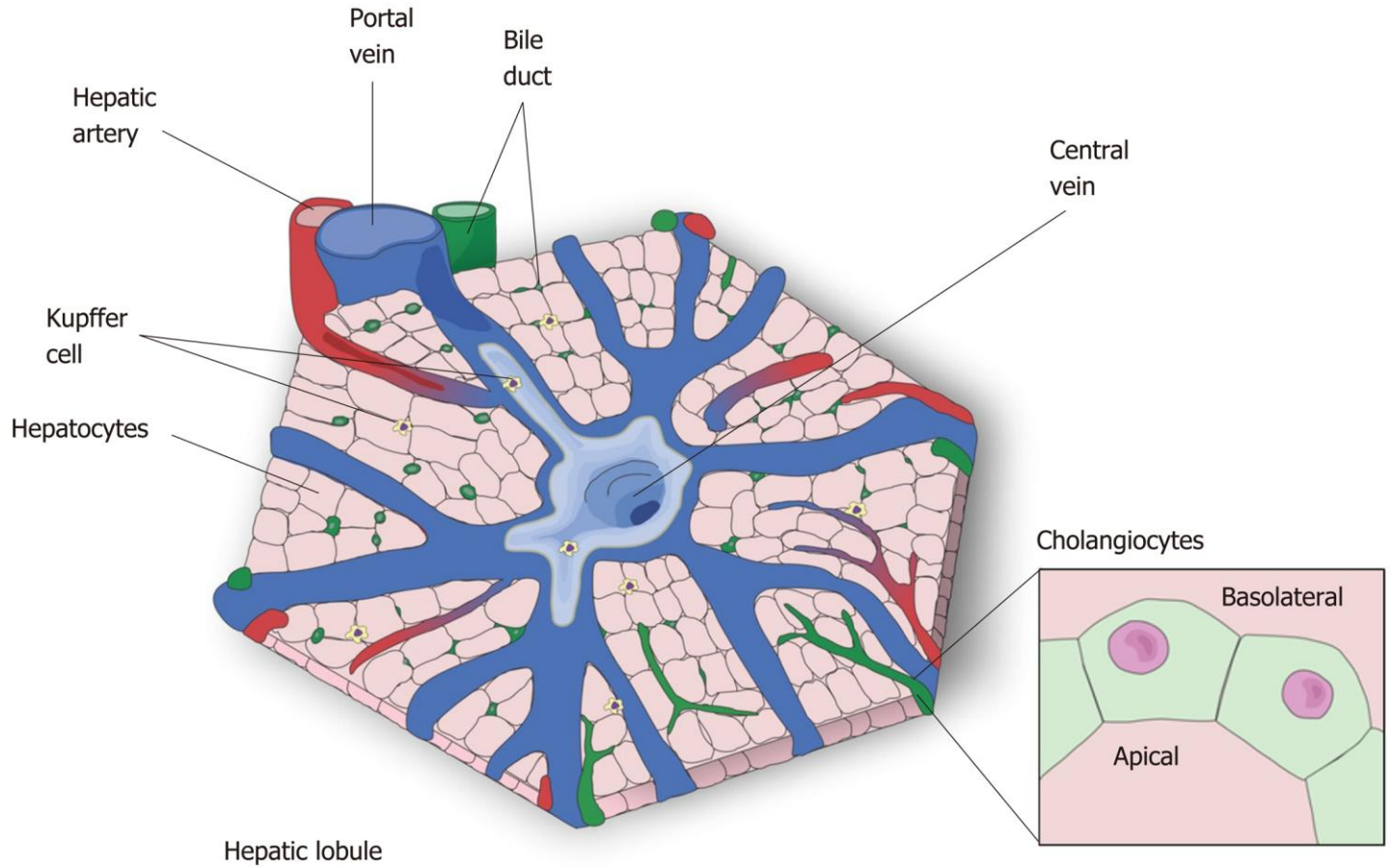

Ureter
Peritoneum
Detrusor muscle
Ureteral openings
Internal urethral sphincter
External urethral sphincter
Transitional epithelium
Lamina propria
Submucosa
(a)
(b)


Outer ear
Malleus
Incus
Stapes
Semicircular Canals
Vestibular Nerve
Cochlear Nerve
Cochlea
Eustachian Tube
Round Window
Tympanic Cavity
Tympanic Membrane
External Auditory Canal



simple cubic epithelium






Thank
you