Embryonic Folding

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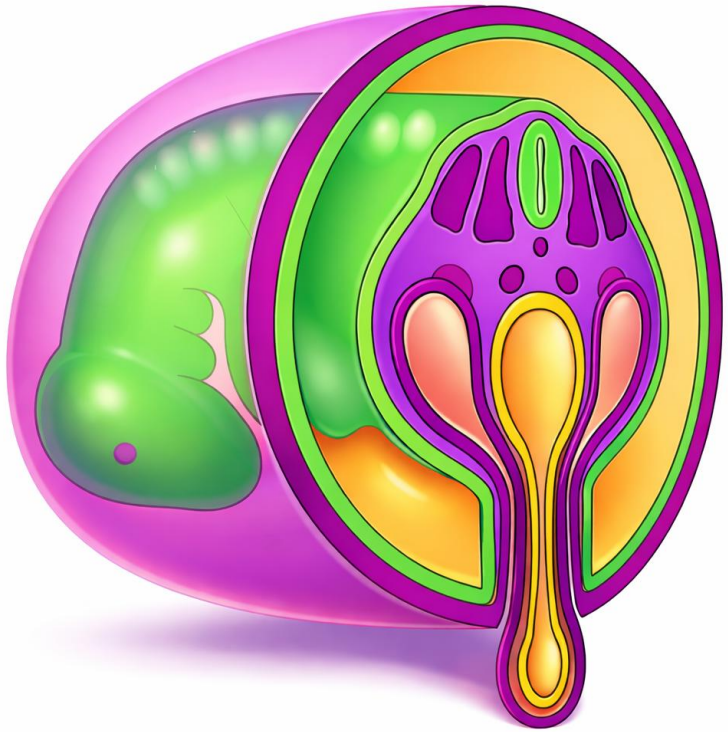
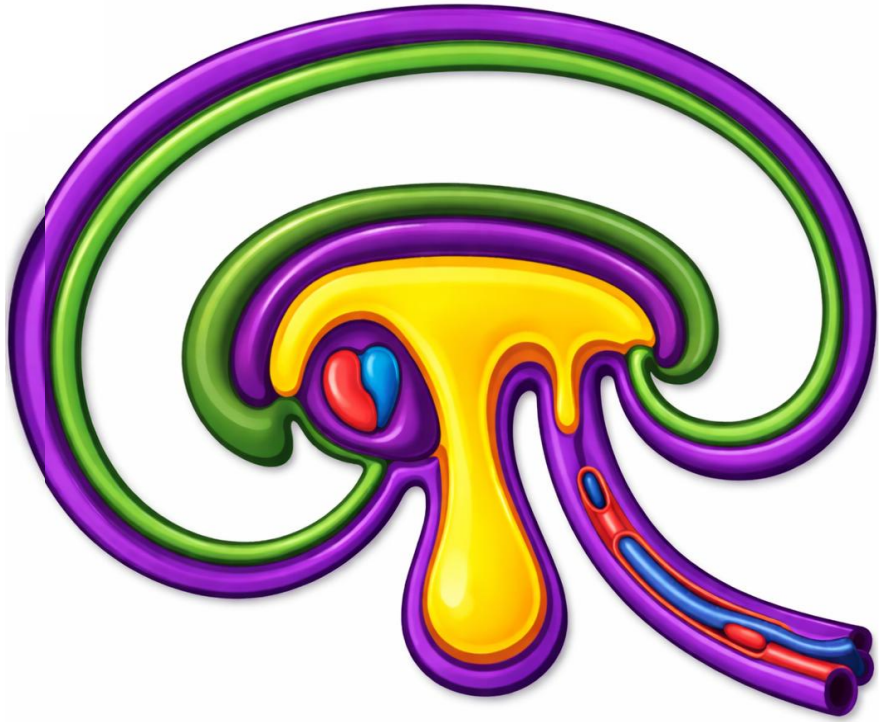
By the end of this lecture, students should be able to:

- ✓ Explain why embryonic folding occurs
- ✓ Describe the types of embryonic folding
- ✓ Understand gut tube formation
- ✓ Describe changes in embryonic cavities
- ✓ Recognize the results and clinical significance of folding

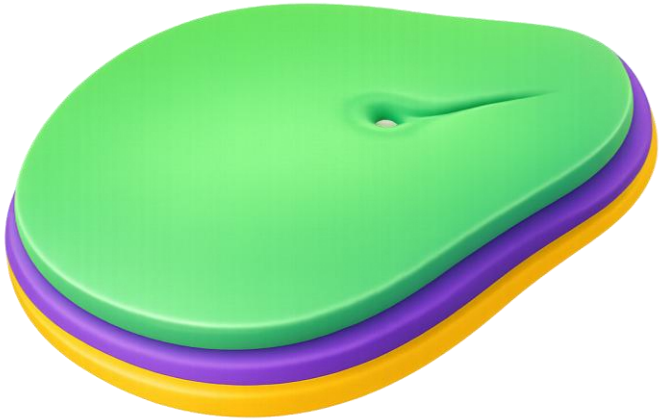




Bilaminar disc
(2nd week)

Ectoderm
Mesoderm
Endoderm

Trilaminar disc
(3rd week)



Embryonic Folding →→→ From trilaminar disc to human body form

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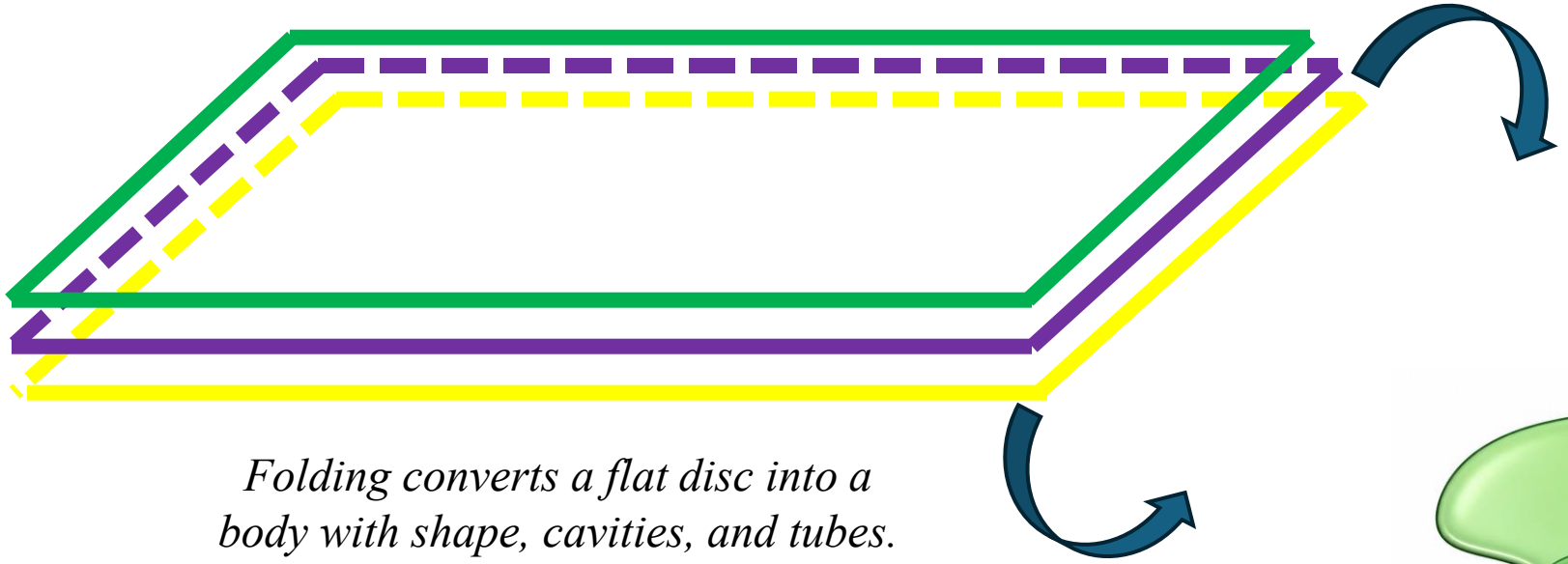
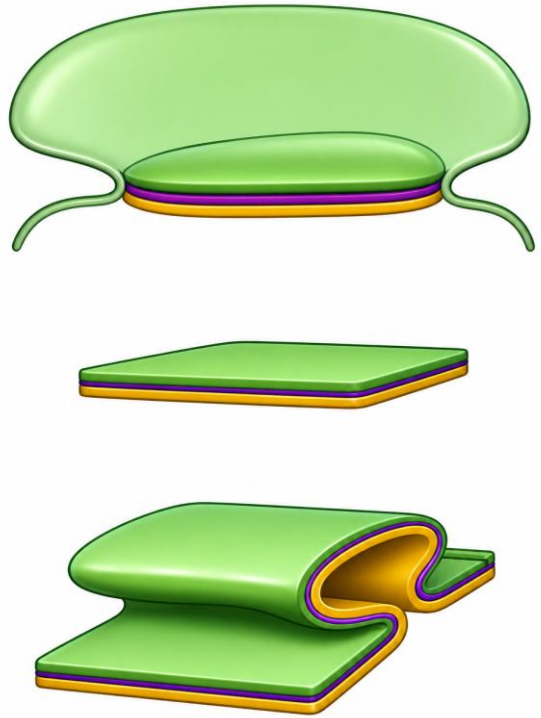
Trilaminar disc (3rd week)



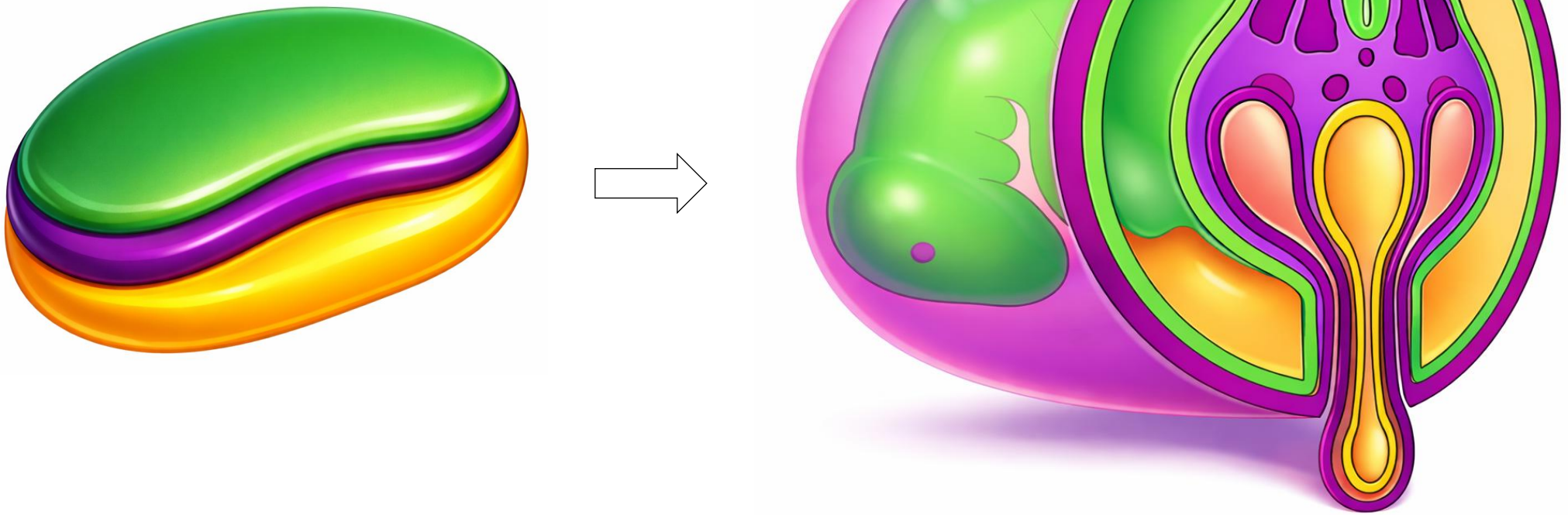
Folding converts a flat disc into a body with shape, cavities, and tubes.



Folding (4th week)

Why embryonic folding occurs ????

1- Rapid growth of the **neural tube** and **somites**
2- Differential growth between: Embryo proper, Yolk sac, Amnion
Result:
👉 a **flat trilaminar disc** becomes a **cylindrical, human-shaped embryo**
Folding transforms a flat disc into a 3D body plan.



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Embryonic Folding

Embryonic folding is the process by which the flat trilaminar embryonic disc is transformed into a cylindrical, three-dimensional embryo.

Fourth week→ **F**olding

- ✓ It occurs mainly during the 4th week of development and involves two simultaneous folding processes:

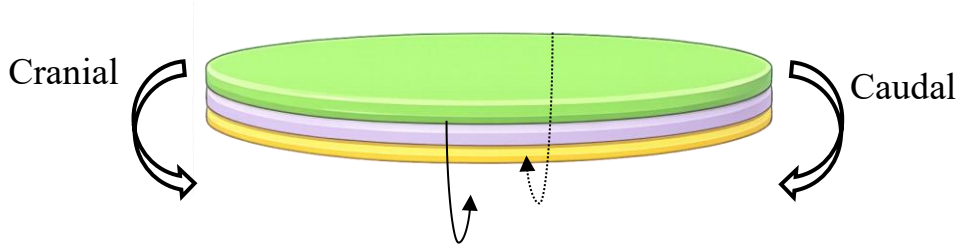
1. **Craniocaudal (longitudinal) folding** (head and tail folds)
2. **Lateral (transverse) folding** (lateral folds)

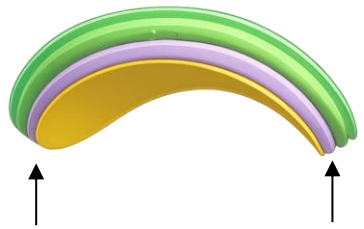
↓ ↓ ↓

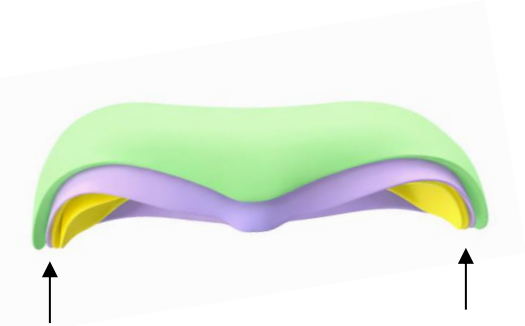
These folds occur due to rapid growth of the neural tube, somites, and amnion, while the yolk sac expands more slowly.

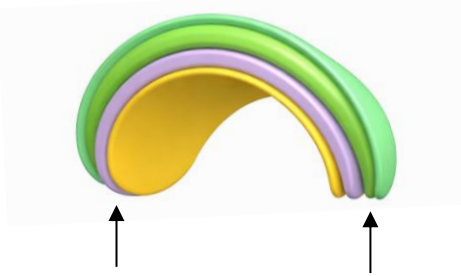
↓ ↓ ↓

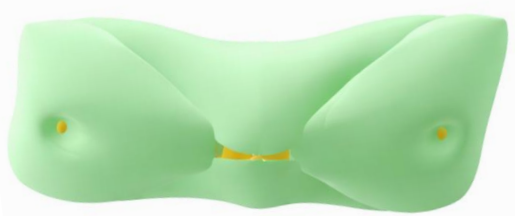
Mechanical forces cause bending and fusion

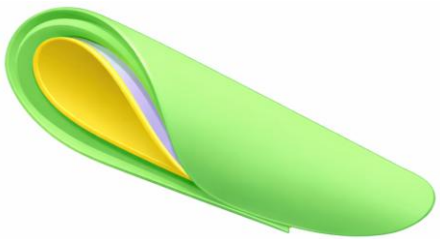












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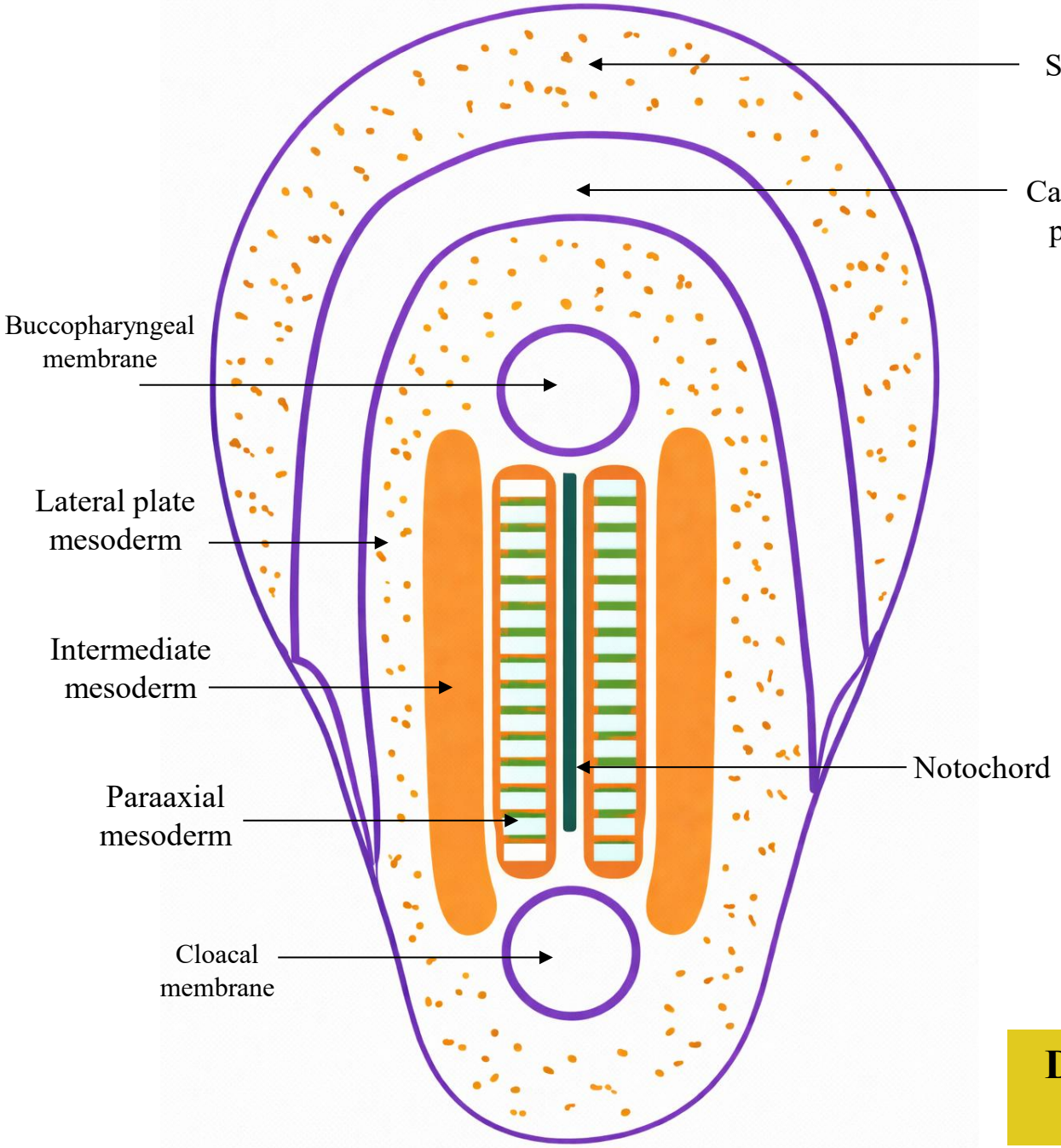
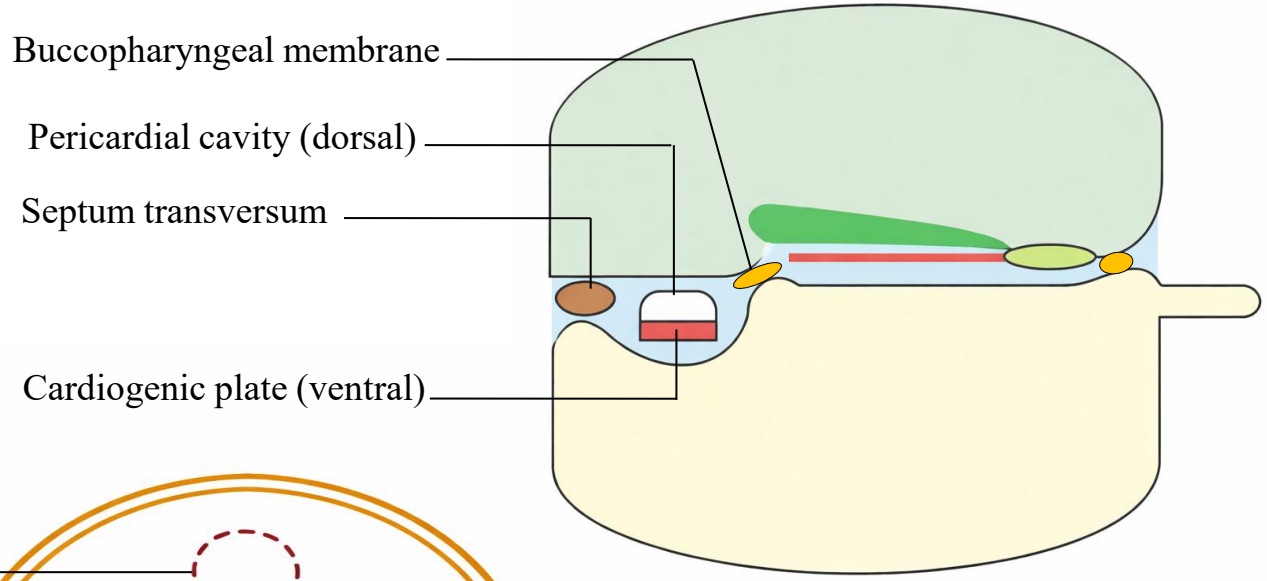
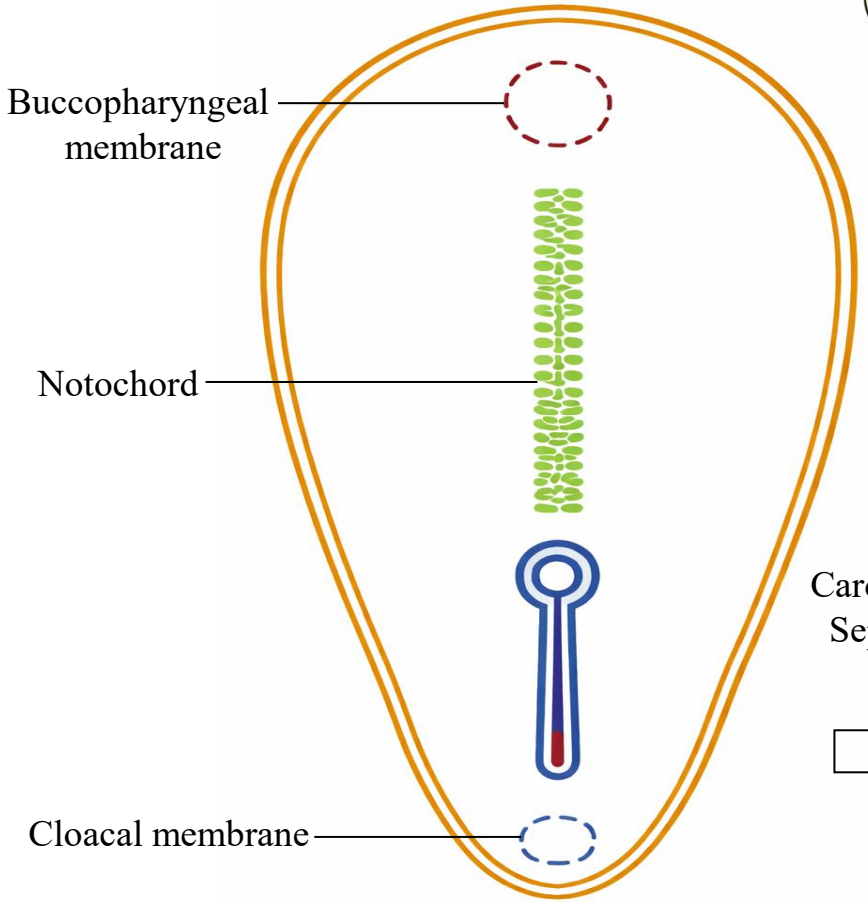
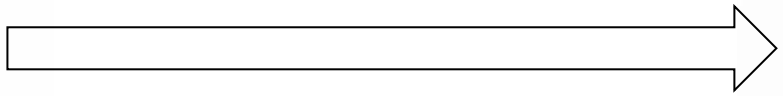


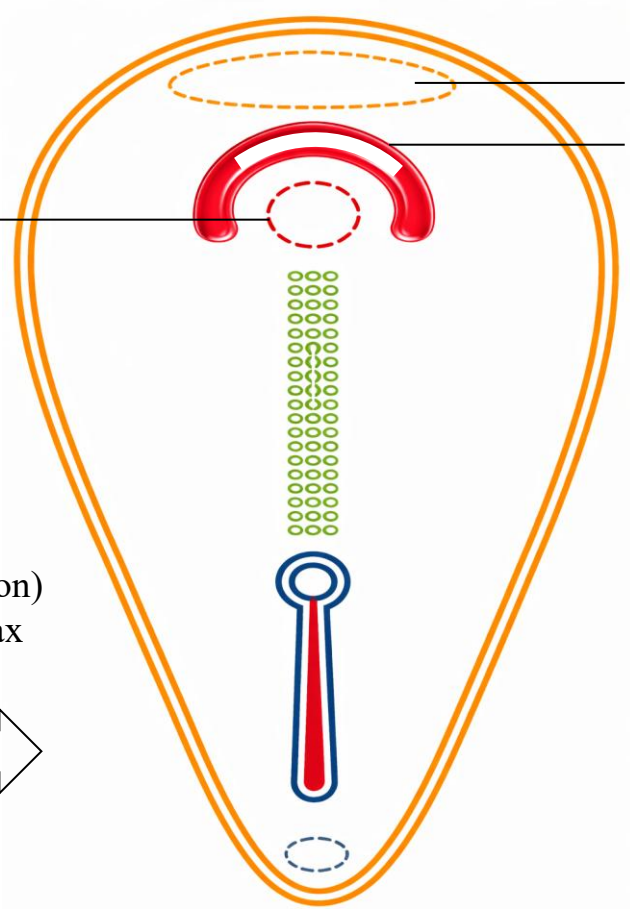
Dorsal view of embryo (ectoderm removed)



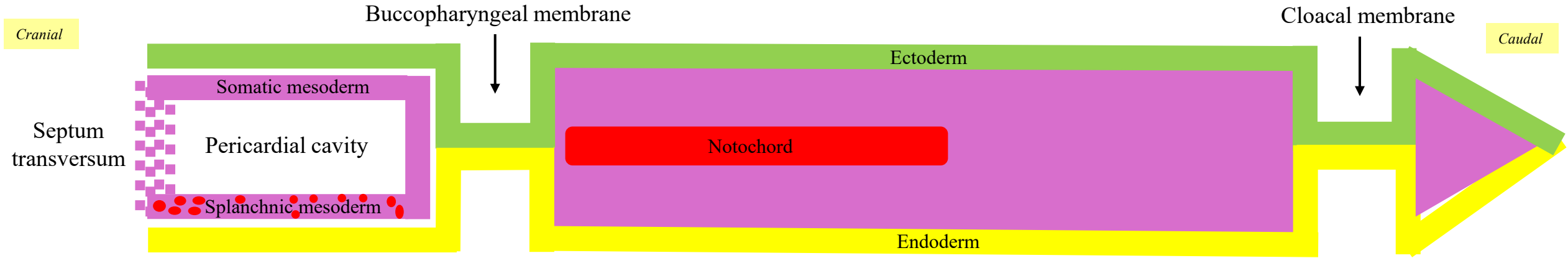


With head folding, they move ventrally:
Cardiogenic plate → becomes thoracic (heart region)
Septum transversum → positioned between thorax and abdomen

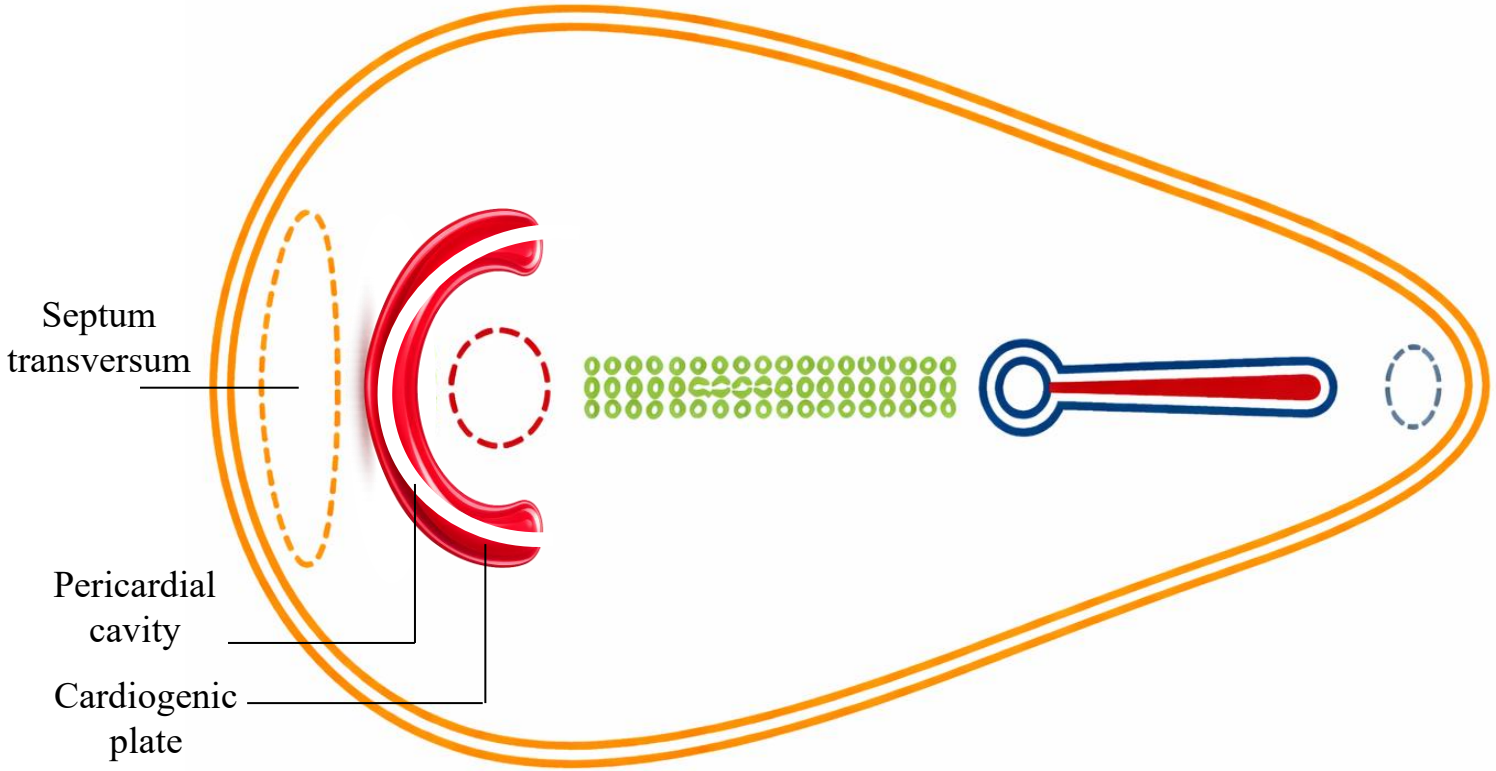




Dorsal view of embryo



Note: Pericardial cavity is dorsal to cardiogenic plate



The **cardiogenic plate** is a horseshoe-shaped region derived from splanchnic mesoderm located cranial to the buccopharyngeal membrane in the early embryo. Cardiogenic plate is the primordium of the heart

The **septum transversum** is a thick mass of mesodermal tissue that forms cranial to the cardiogenic plate early in development and later becomes positioned between the thoracic cavity and abdominal cavity (future central tendon of diaphragm).

Longitudinal Folding

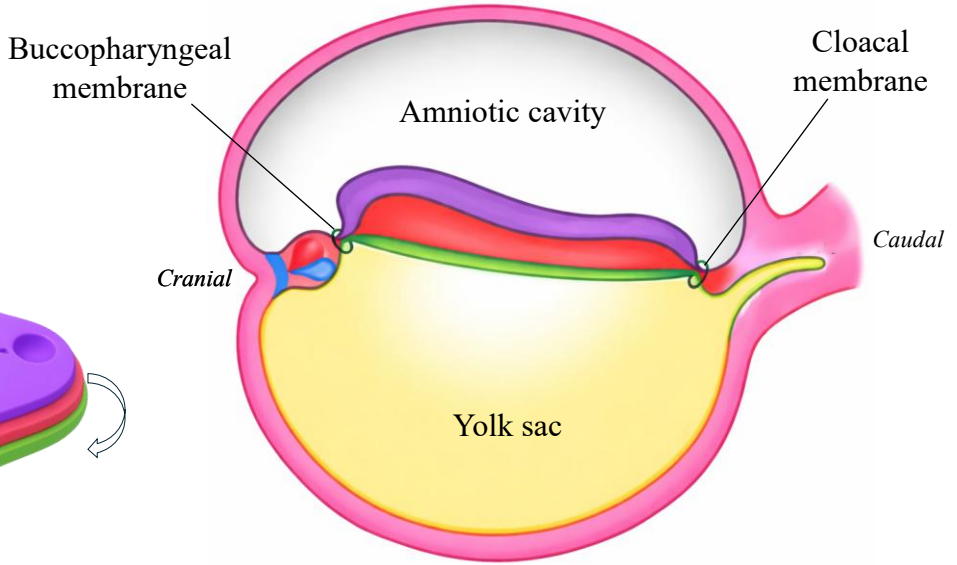
Occurs in the cranio-caudal (head-to-tail) direction

Head (Cranial) Folding

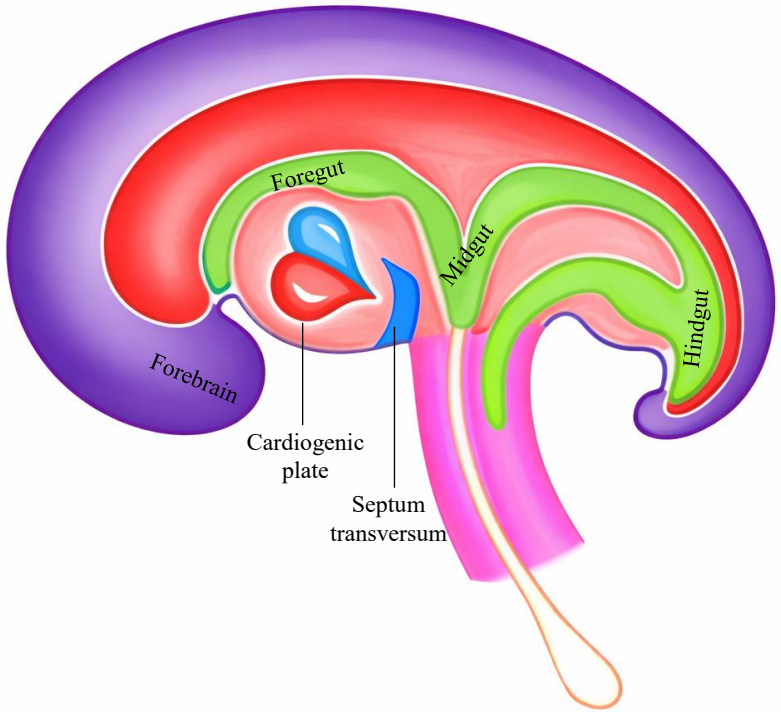
- ✓ Cranial end of embryo bends ventrally.
- ✓ Part of the endoderm-lined yolk sac is incorporated into the embryo.

This incorporated portion forms the **foregut**.

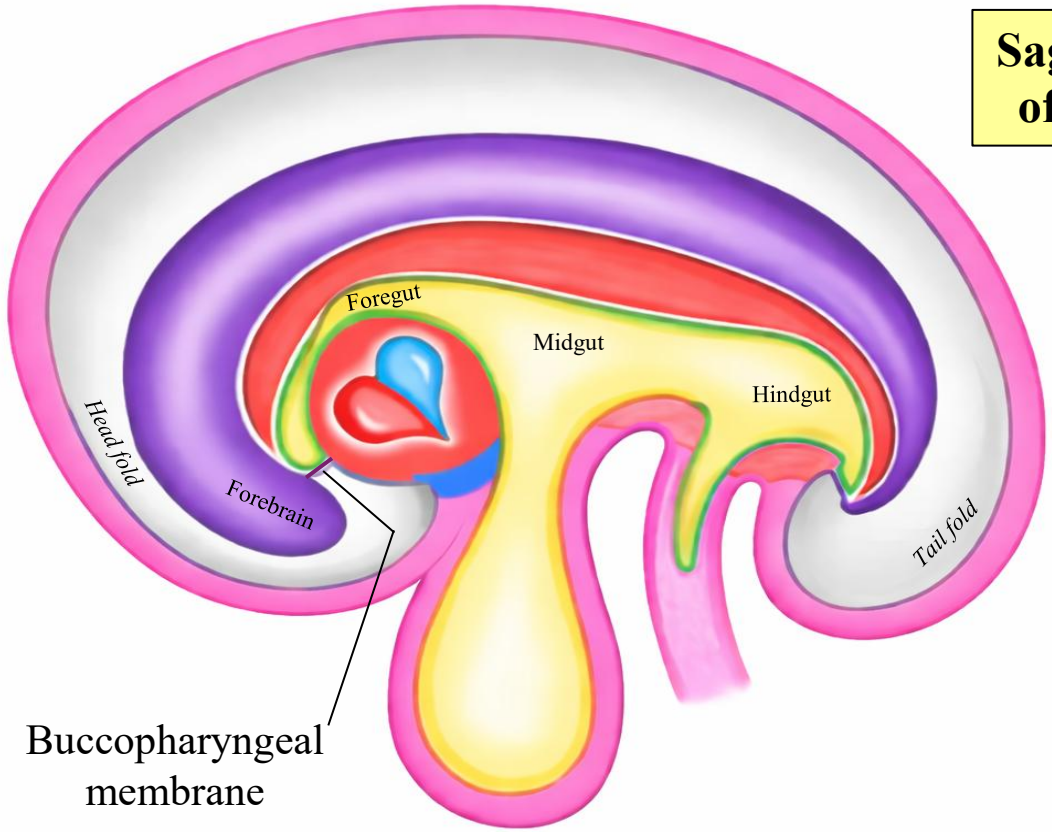
- ✓ The buccopharyngeal membrane moves to the ventral surface.
- ✓ Cardiogenic plate (primitive heart field) and septum transversum shift from a cranial position to a ventral position.



*Converts the embryo into a **C-shaped structure***



Sagittal sections of the embryo



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Ectoderm
Mesoderm
Endoderm

Longitudinal Folding

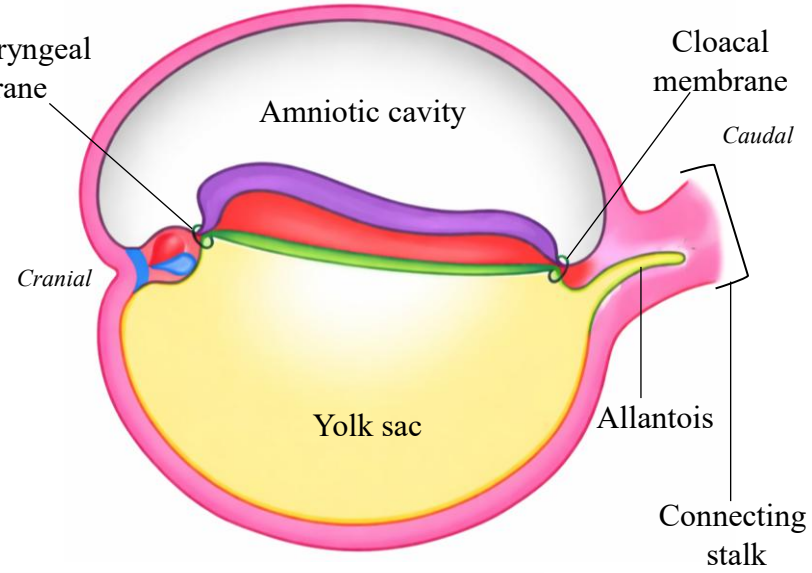
Occurs in the cranio-caudal (head-to-tail) direction

Tail (Caudal) Folding

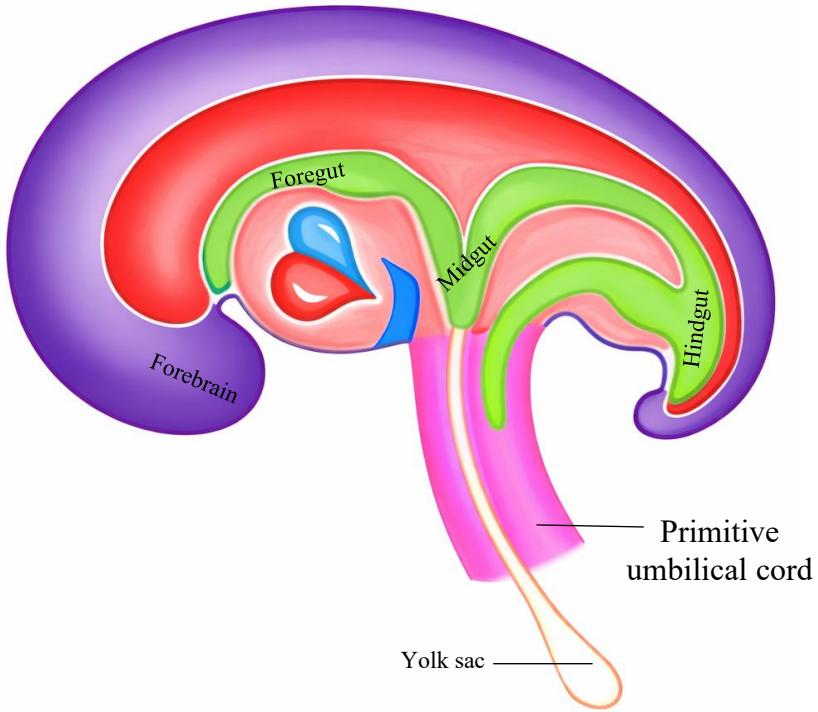
- ✓ Caudal end of embryo bends ventrally.
- ✓ Part of the yolk sac is incorporated into the embryo.

This incorporated portion forms the **hindgut**.

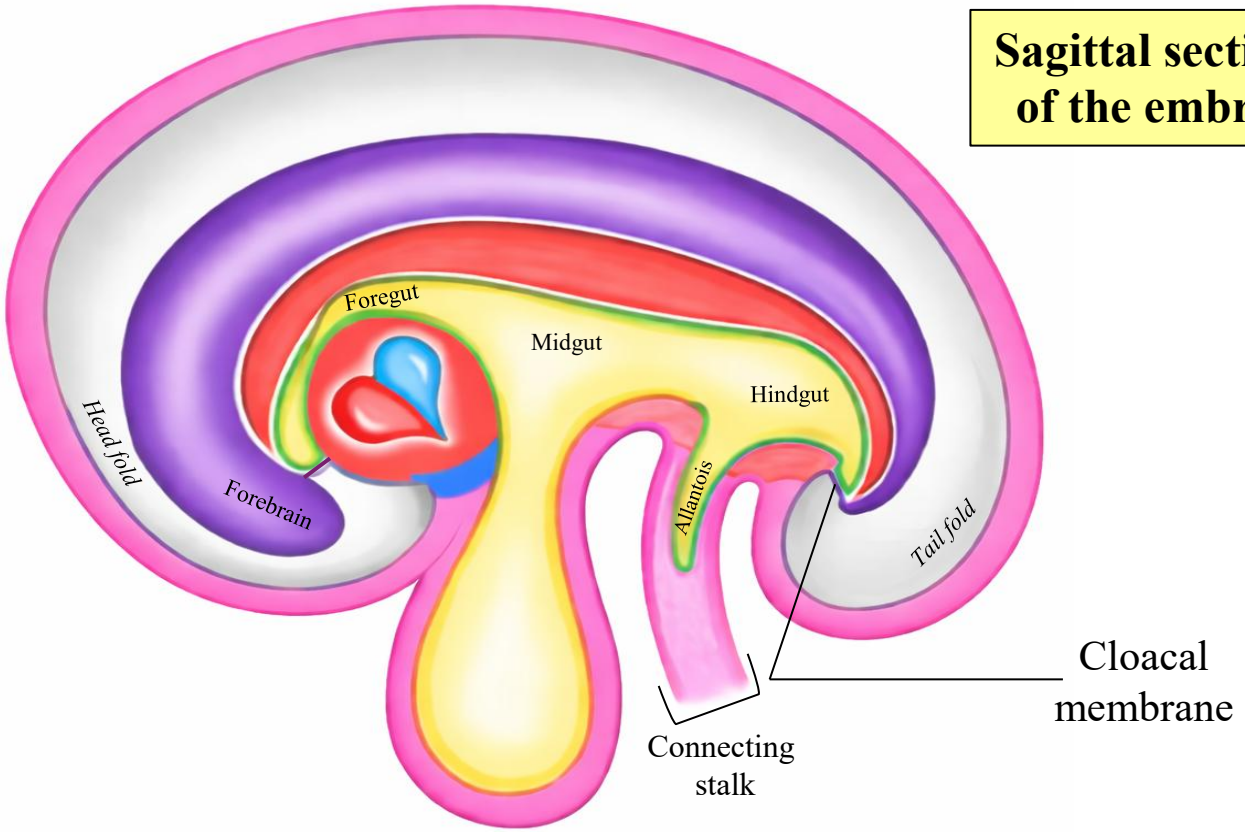
- ✓ The cloacal membrane moves to the ventral surface.
- ✓ The connecting stalk and allantois shift to a ventral position.



*Converts the embryo into a **C-shaped structure***



Sagittal sections of the embryo



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Ectoderm
Mesoderm
Endoderm

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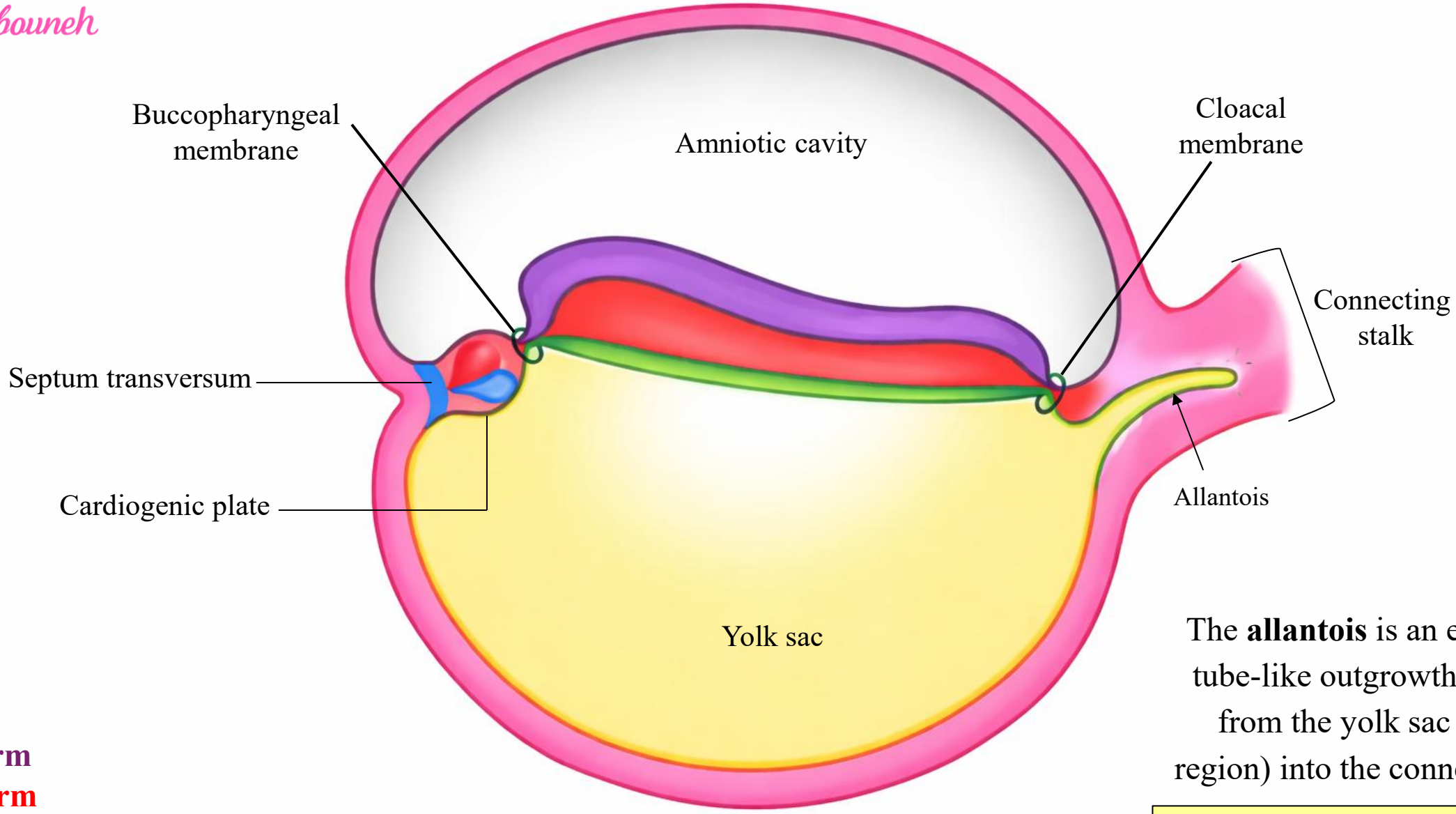

Ectoderm
Mesoderm
Endoderm

The **allantois** is an endodermal tube-like outgrowth extending from the yolk sac (hindgut region) into the connecting stalk.

Sagittal section of the embryo

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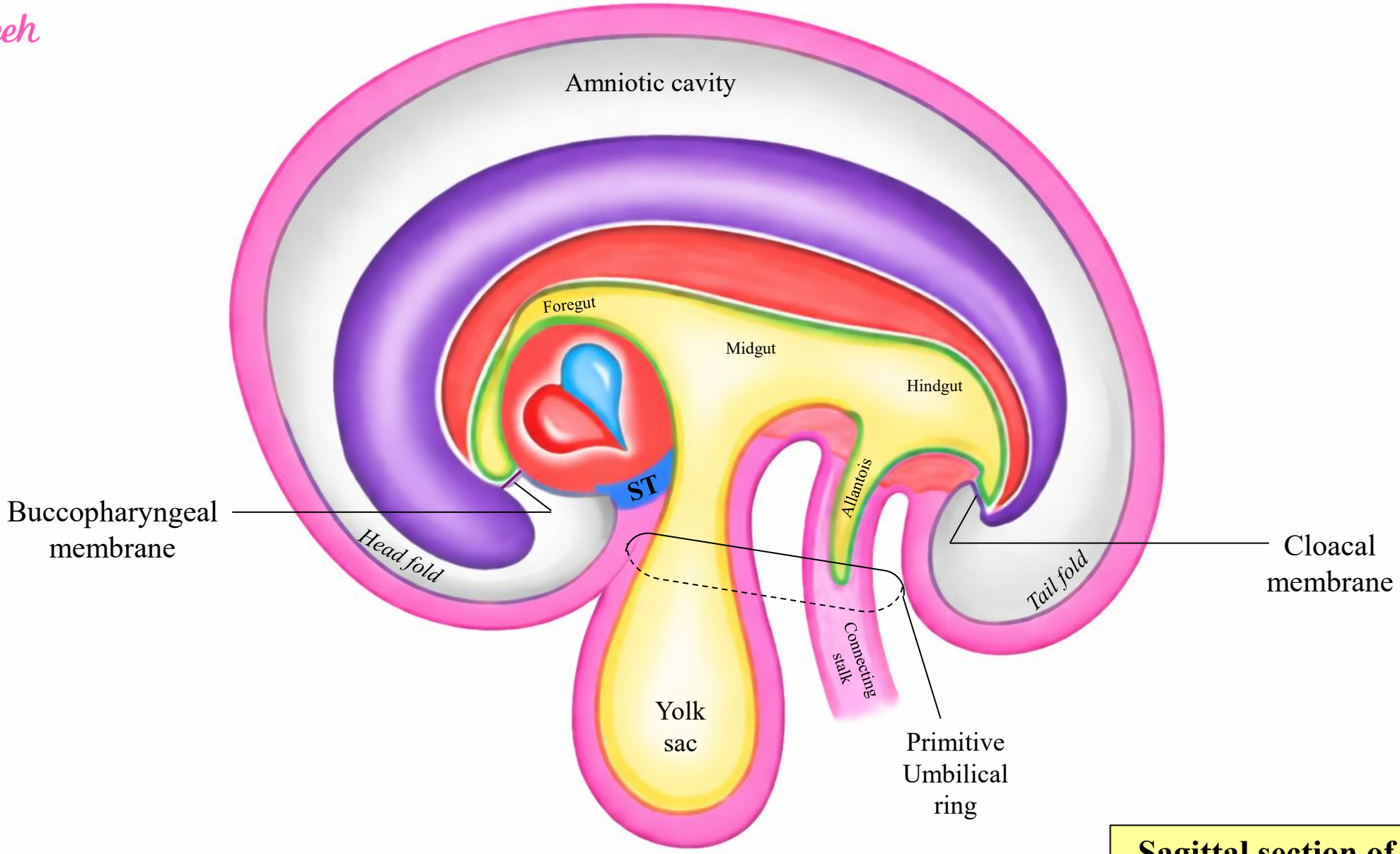

Ectoderm
Mesoderm
Endoderm

ST: Septum transversum

Sagittal section of the embryo

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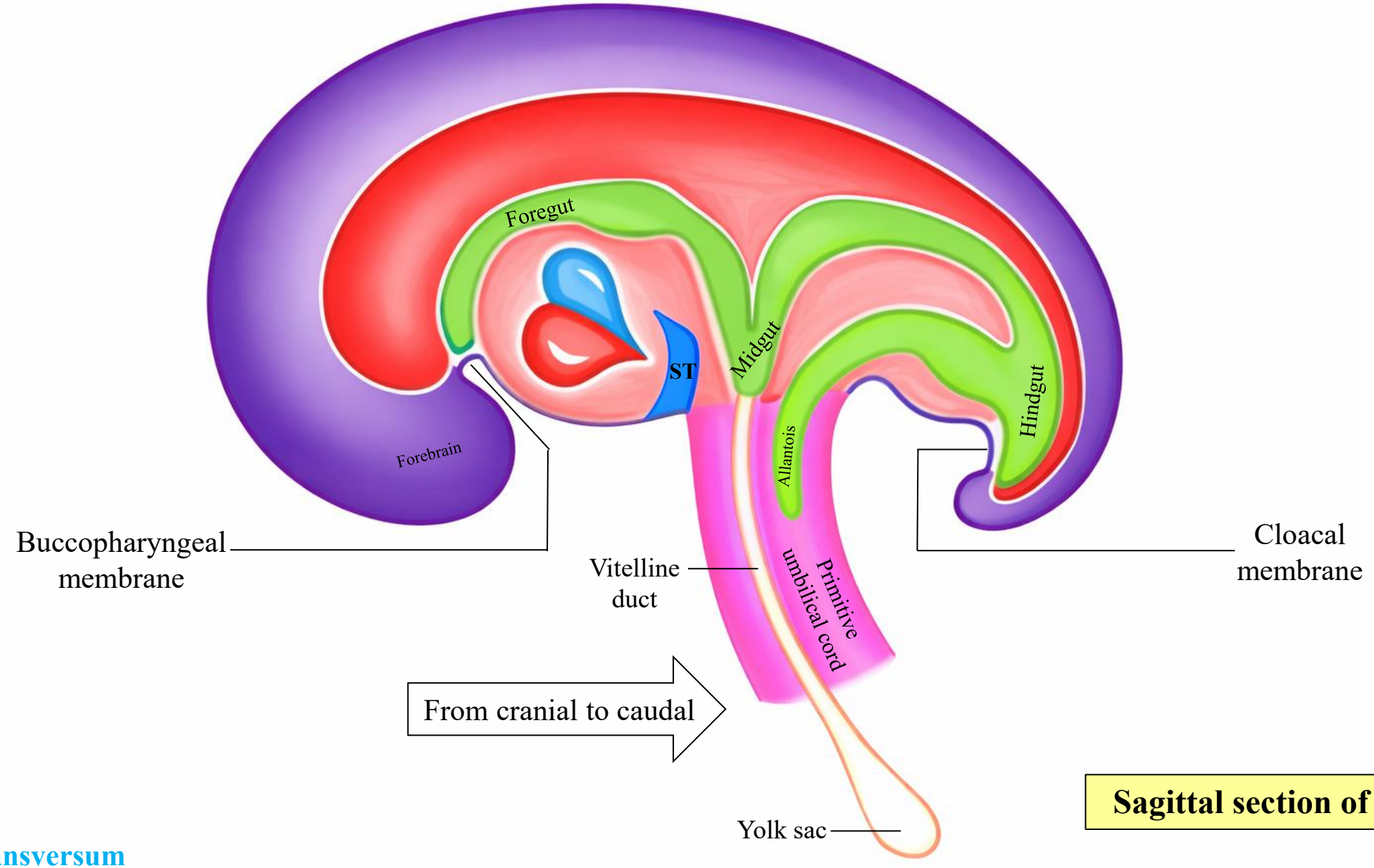
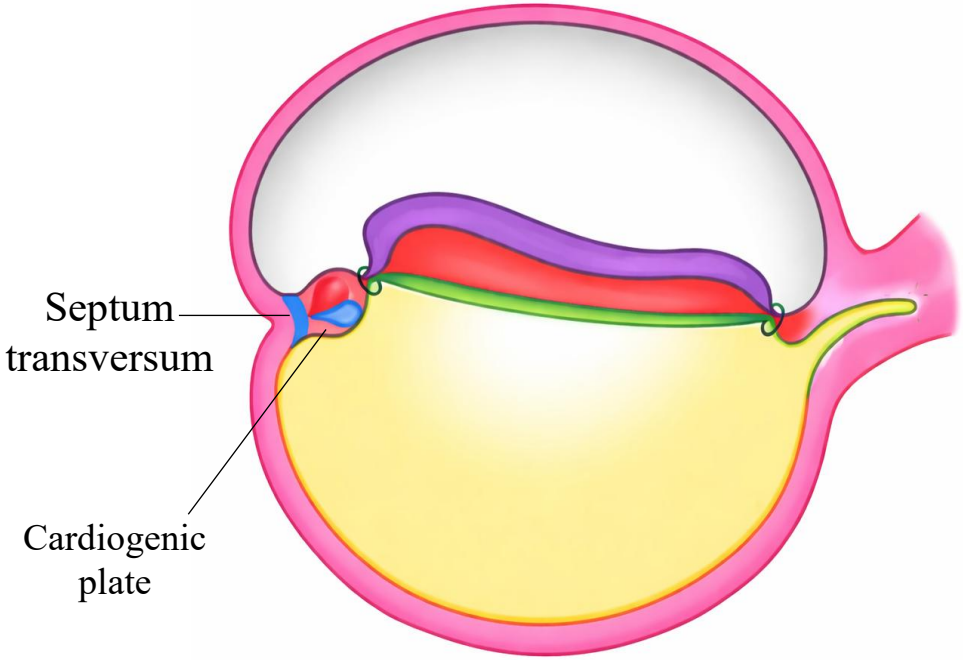


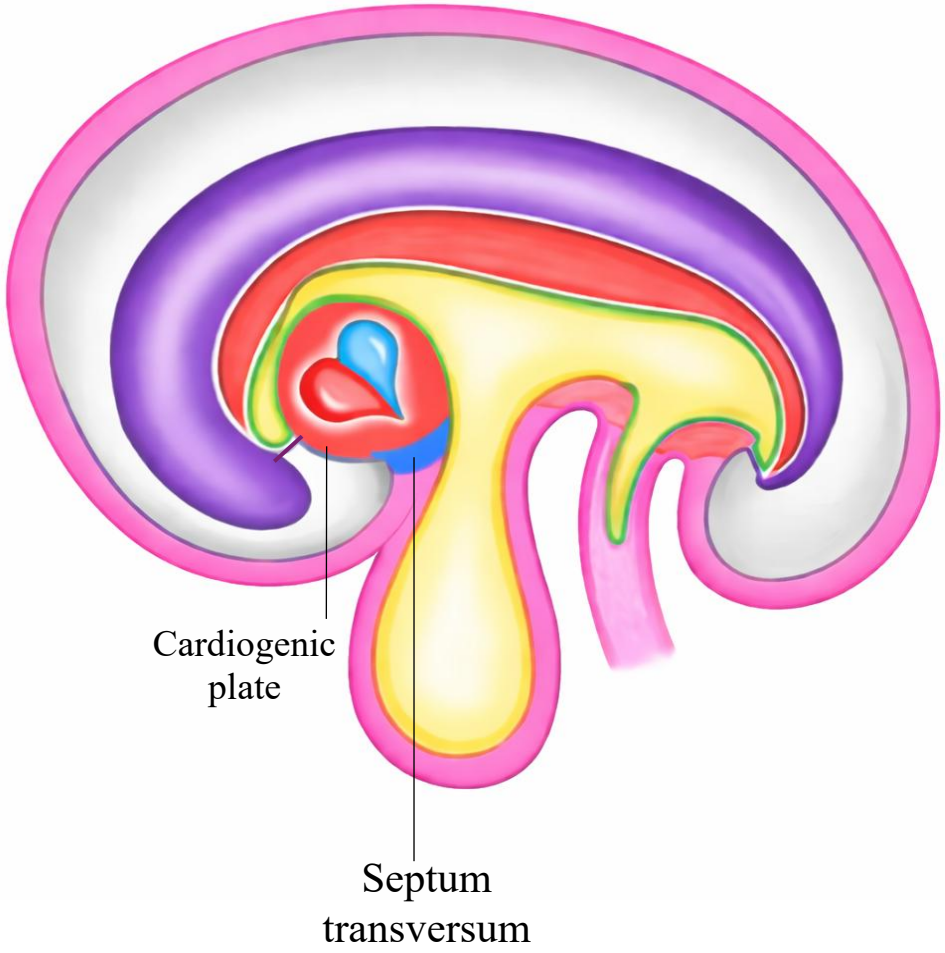
Ectoderm
Mesoderm
Endoderm

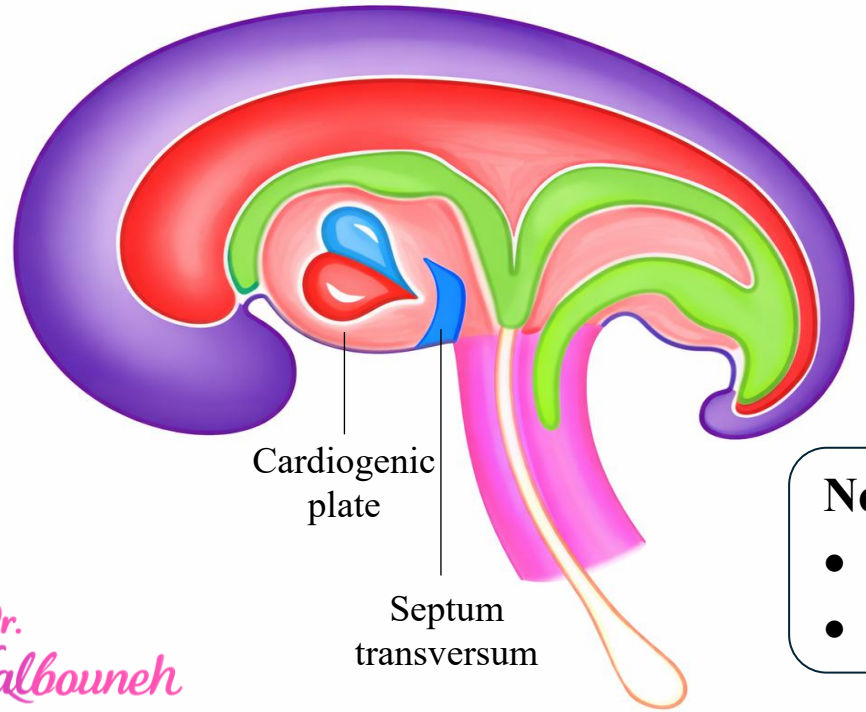
ST: Septum transversum

Sagittal section of the embryo

Ectoderm
Mesoderm
Endoderm

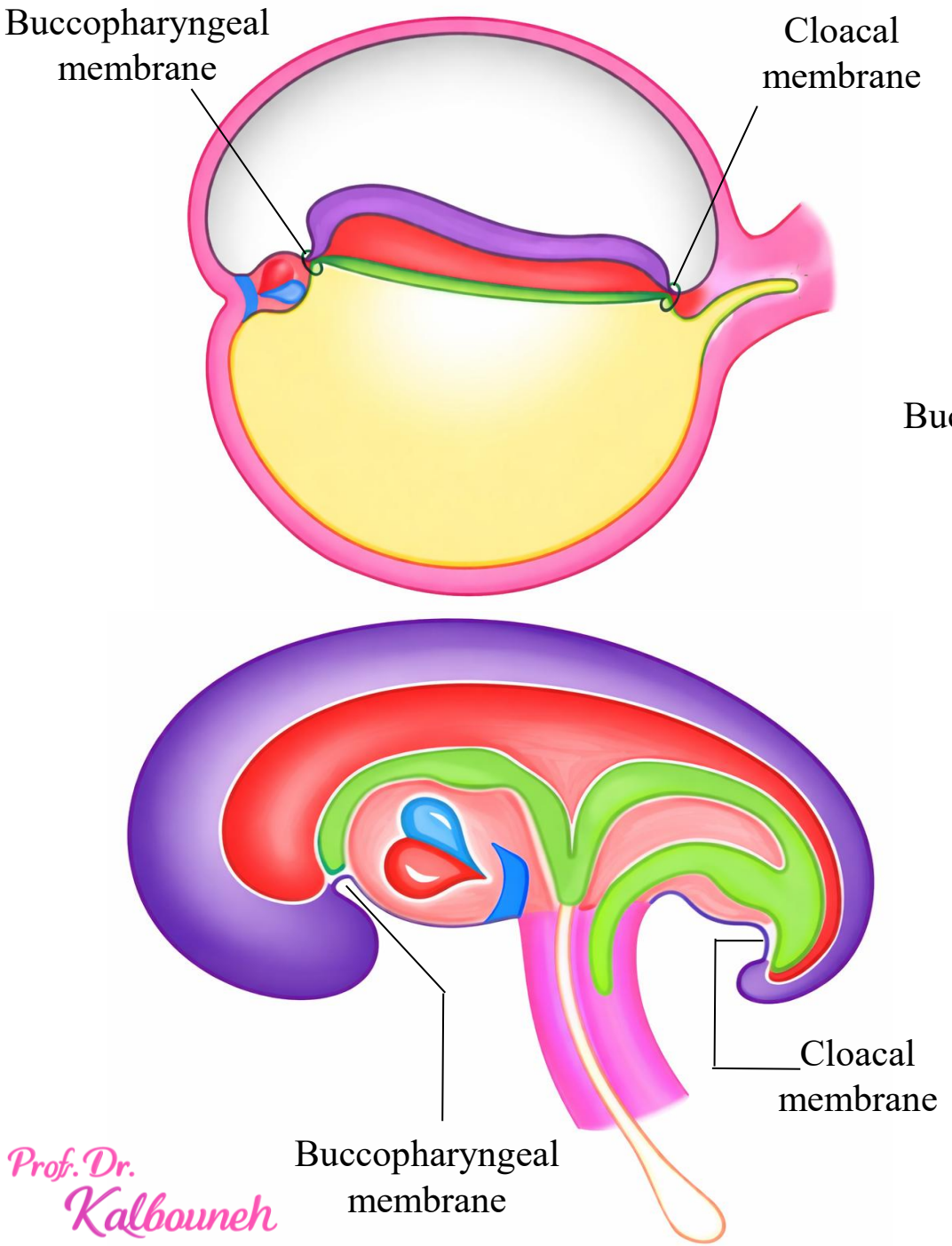


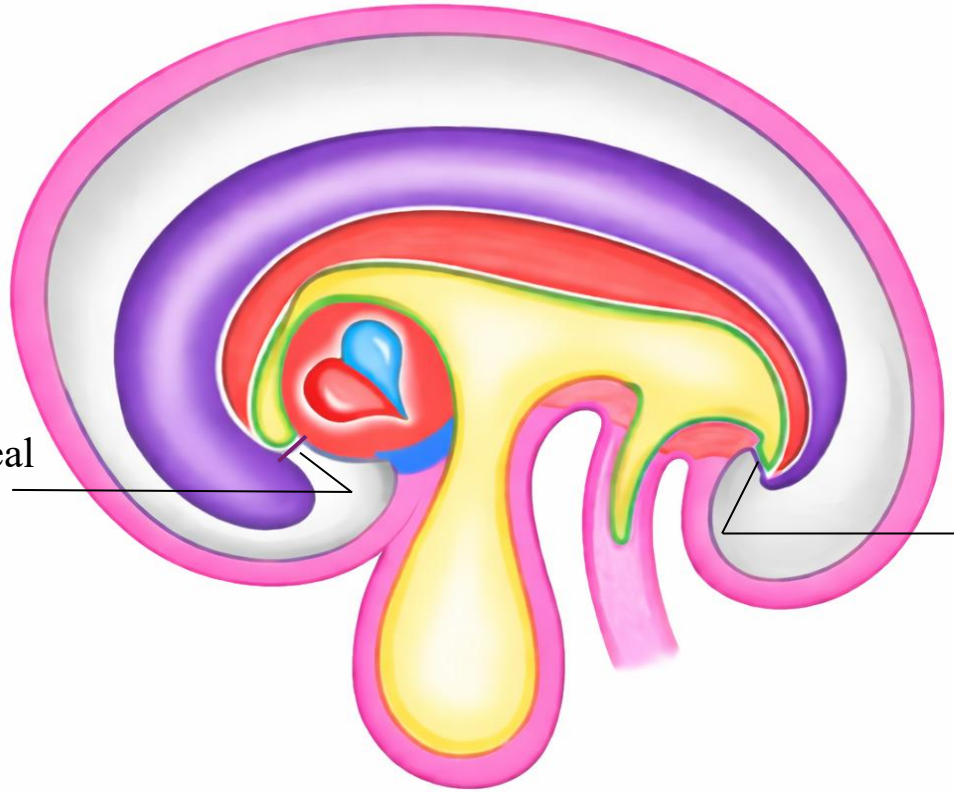




Notes

- **Cardiogenic plate** moves **ventrally and caudally**
- **Septum transversum** moves **ventrally and caudally** → future **diaphragm**



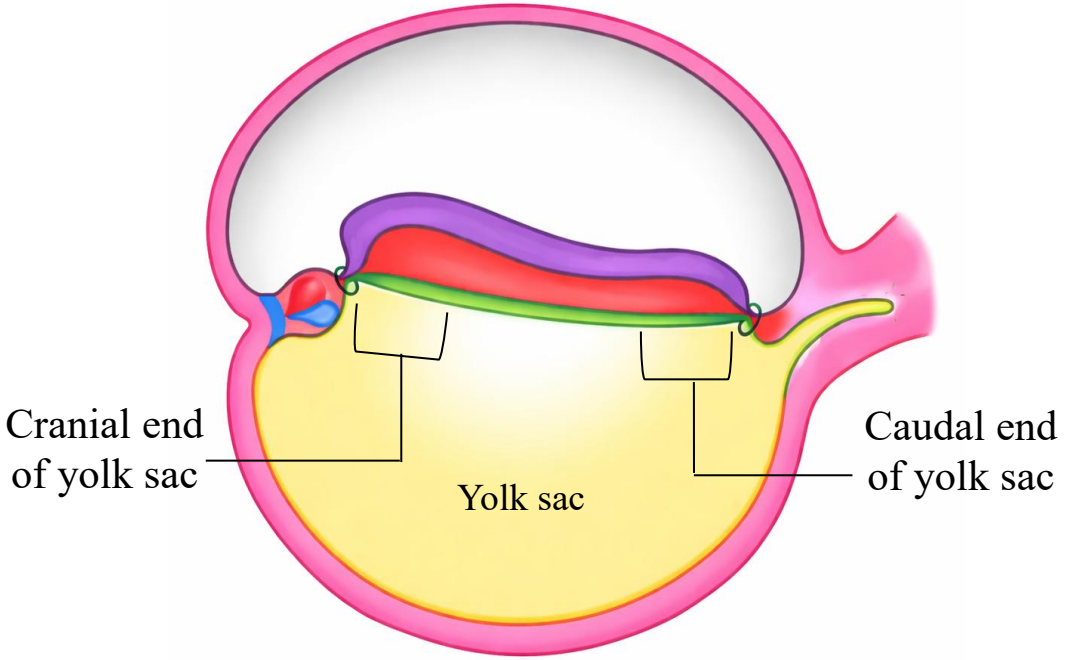


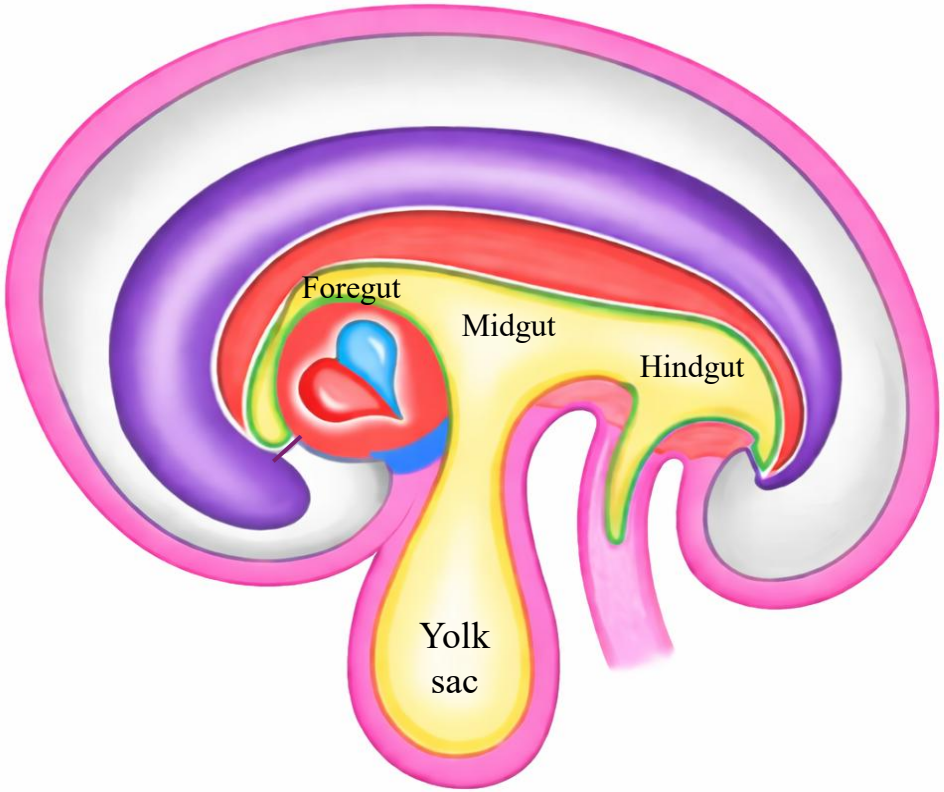
Membrane	Rupture time	Location
Buccopharyngeal	Week 4	Marks the future mouth opening
Cloacal	Week 7	Marks the future anus and urogenital openings

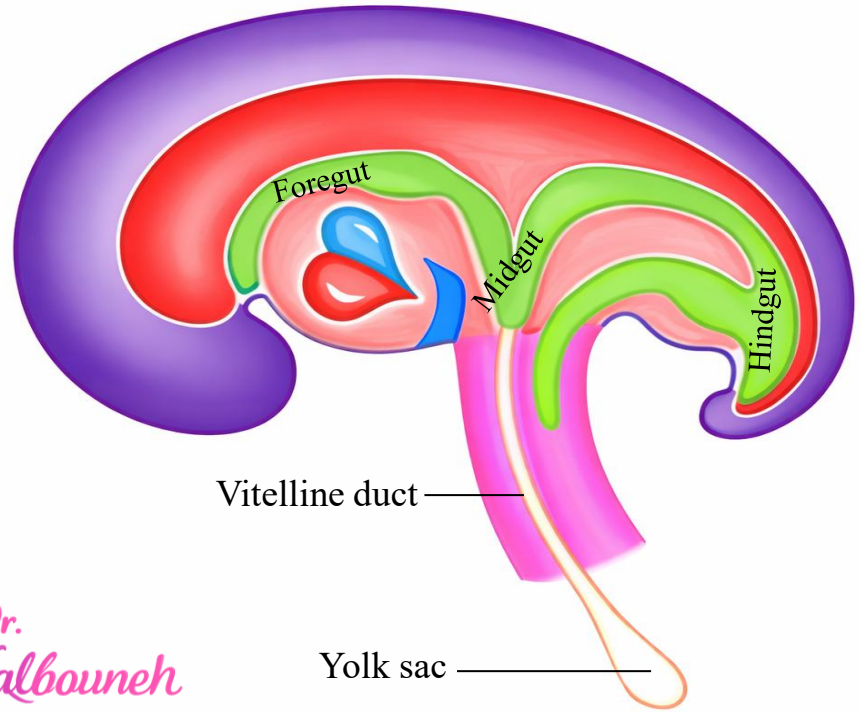
Notes

- **Buccopharyngeal membrane** moves **ventrally and caudally**
- **Cloacal membrane** moves **ventrally and cranially**

Ectoderm
Mesoderm
Endoderm







Notes

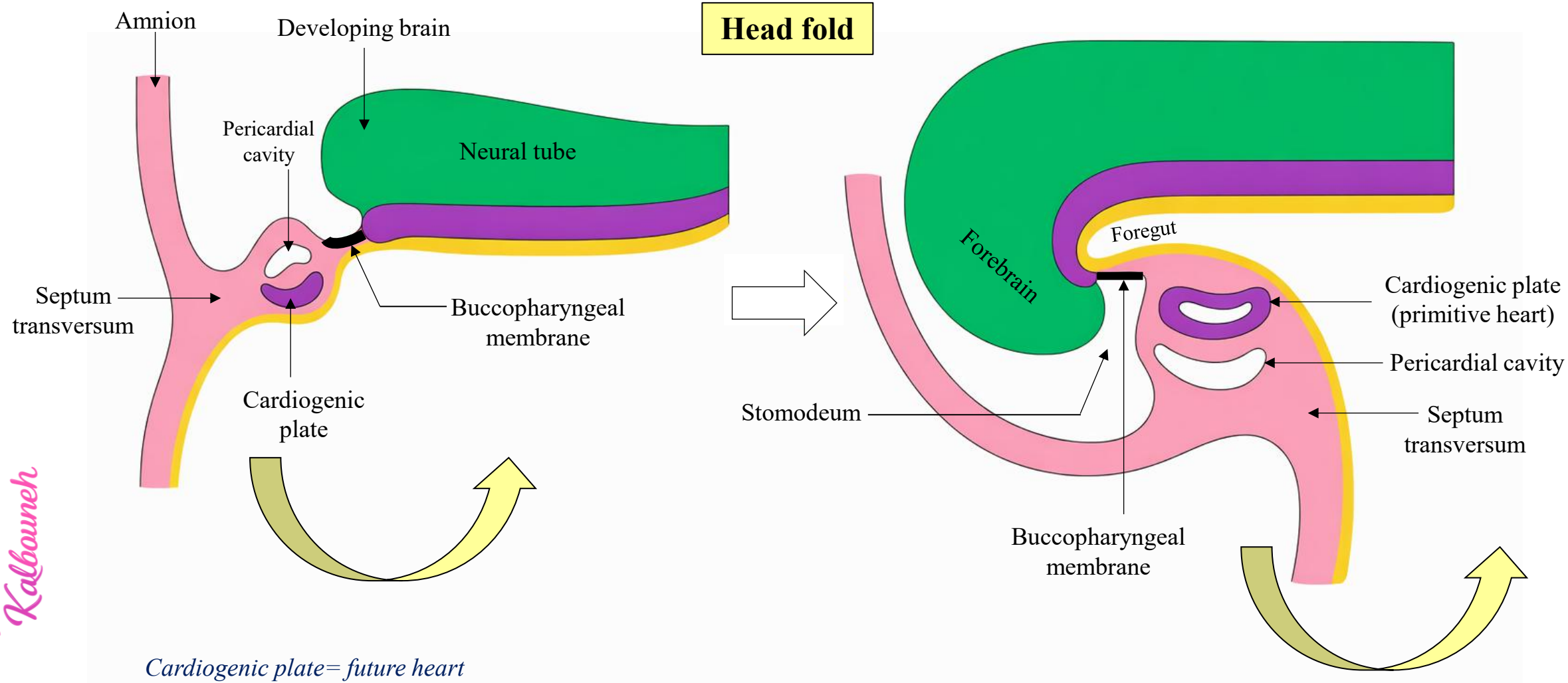
Parts of endoderm of the yolk sac becomes incorporated into the embryo during folding.

Foregut: from the cranial end of the yolk sac

Midgut: remains temporarily connected to yolk sac via the vitelline duct

Hindgut: from the caudal end of the yolk sac

Head fold

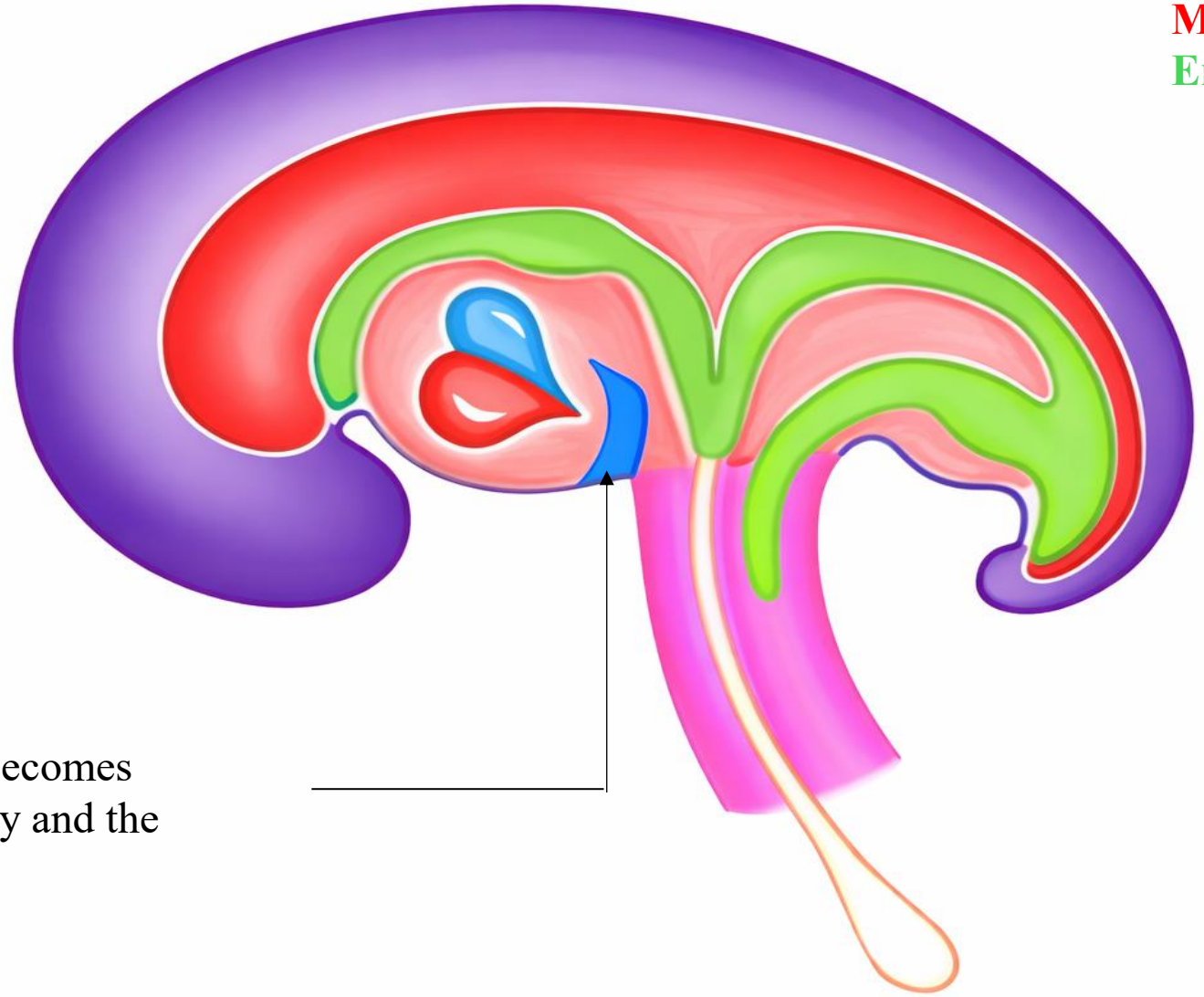


Cardiogenic plate= future heart

Before folding:
The following structures are present in the midline of the embryo arranged in a craniocaudal direction:
a. Septum transversum
b. Cardiogenic plate + pericardial cavity dorsal to cardiogenic plate.
c. Buccopharyngeal membrane.

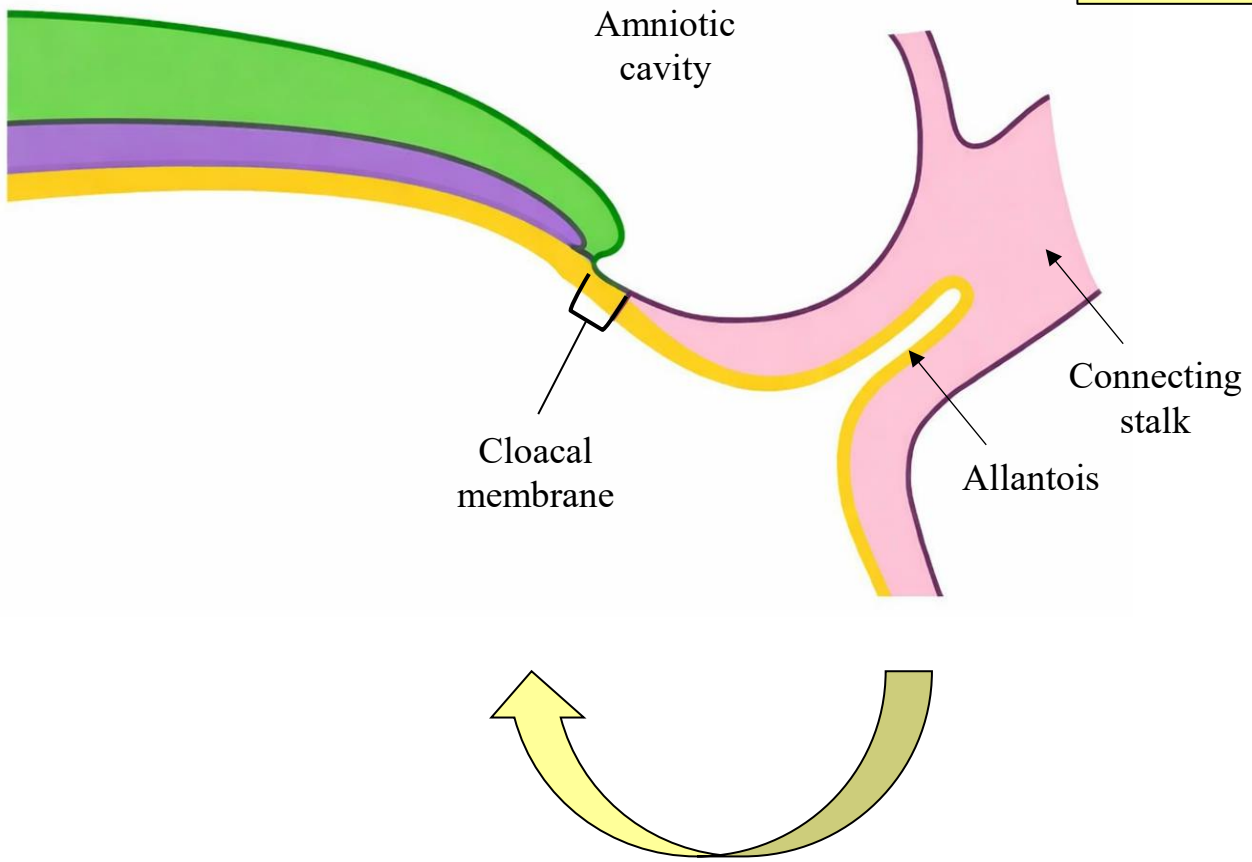
After folding:
The following structures lie ventral to the embryo and are arranged in a craniocaudal order:
a. Buccopharyngeal membrane
b. Cardiogenic plate (becomes dorsal to pericardial cavity)
c. Septum transversum

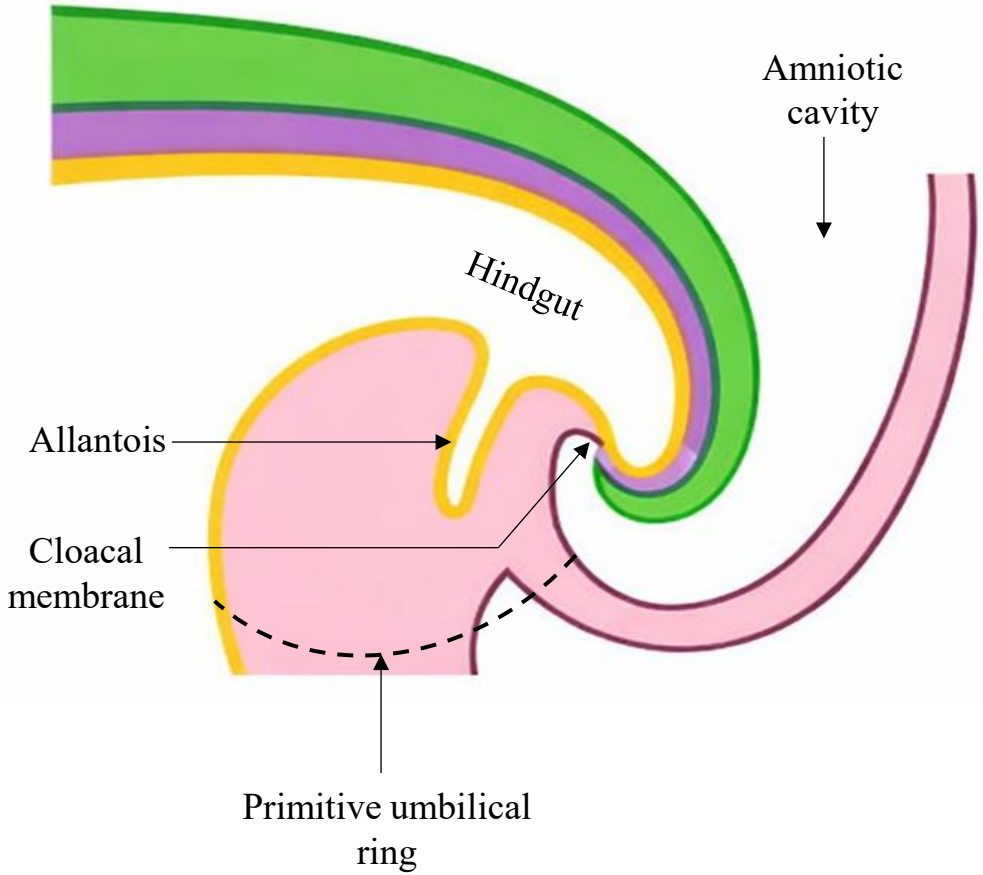
Ectoderm
Mesoderm
Endoderm



Note: The septum transversum becomes located between the thoracic cavity and the umbilical cord region (future diaphragm)

Tail fold

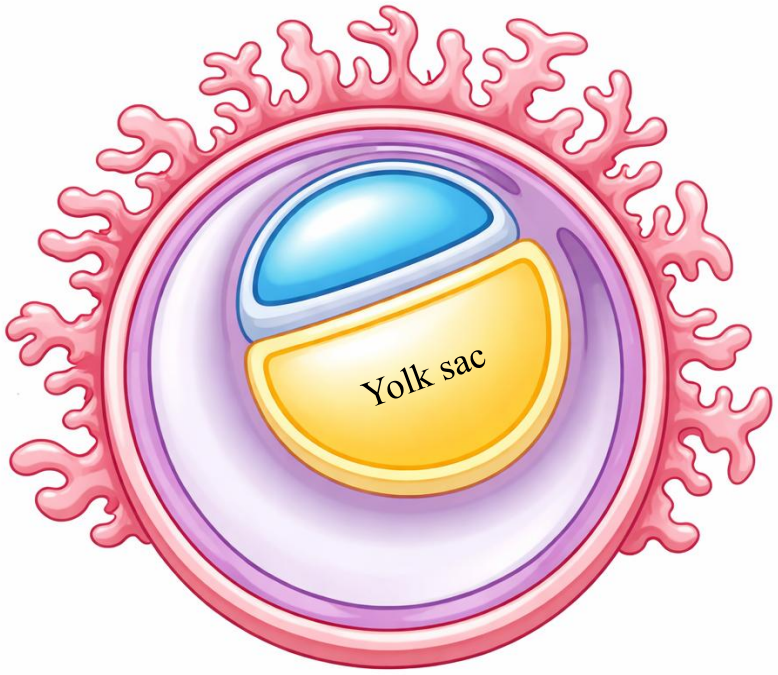




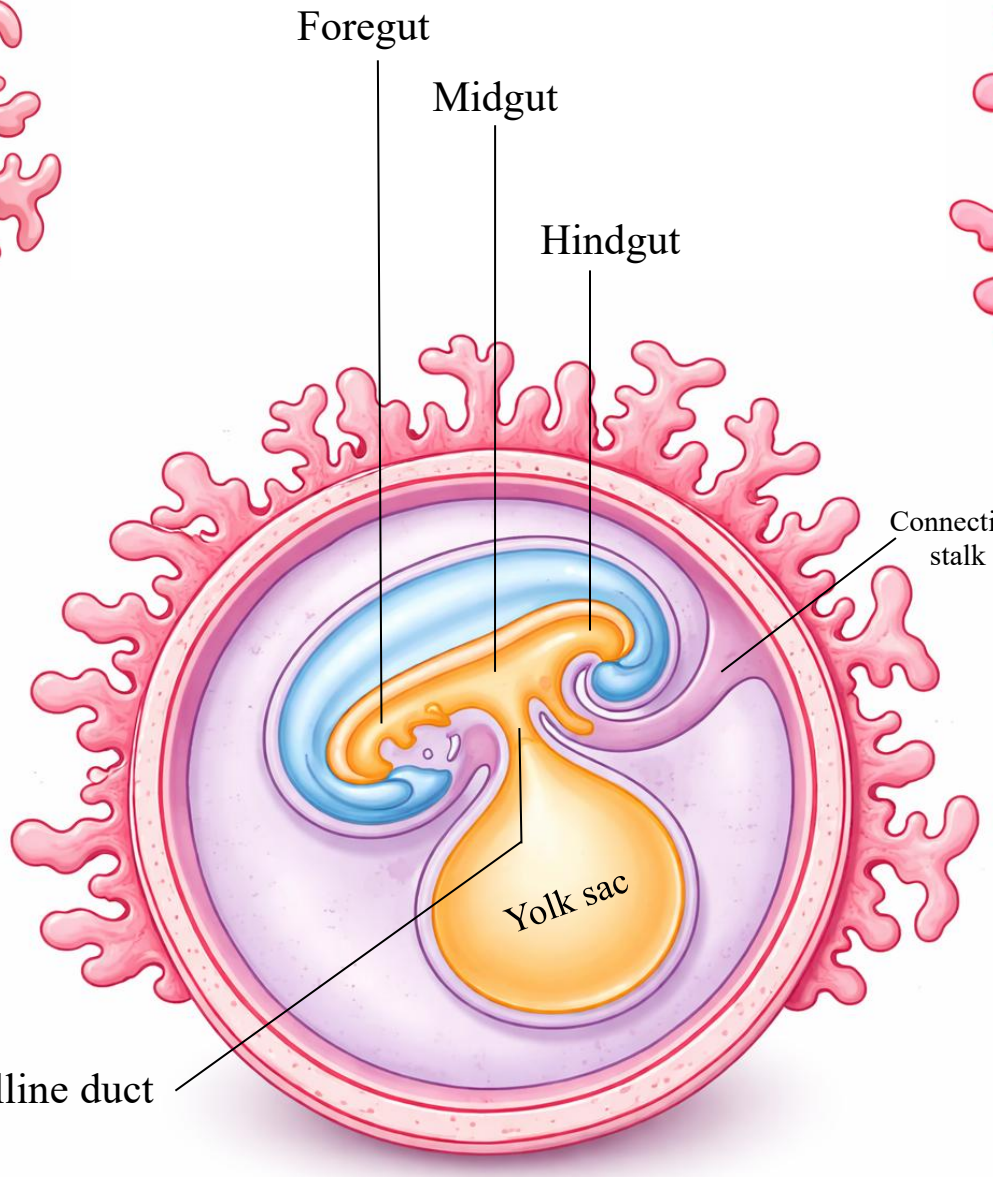
Position Changes During Cephalocaudal Folding

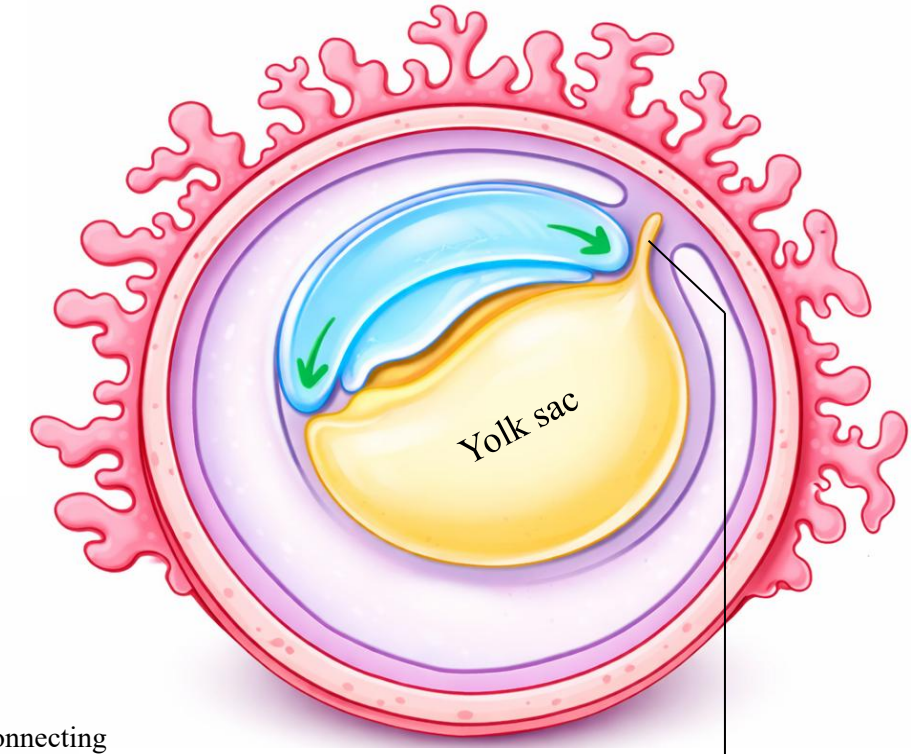
Structure	Before Folding	After Folding
Septum transversum	Cranial to the primitive heart	Caudal to the primitive heart
Primitive heart	Ventral to the pericardial cavity	Dorsal to the pericardial cavity
Pericardial cavity	Dorsal to the primitive heart	Ventral to the primitive heart
Buccopharyngeal membrane	Caudal to both primitive heart and pericardial cavity	Cranial to both primitive heart and pericardial cavity
Connecting stalk	Caudal	Ventral
Allantois	Caudal	Ventral

Note: Craniocaudal folding repositions cranial structures ventrally and caudally, bringing the primitive heart and septum transversum into the future thoracic region and shifting the connecting stalk and allantois to the ventral surface.



Note: During embryonic folding, the yolk sac is progressively pinched off from the embryo; parts are incorporated to form the foregut and hindgut, while the midgut remains temporarily connected to the yolk sac via the vitelline duct.





Allantois is a small endoderm-derived, tube-like outgrowth from the yolk sac that extends into the connecting stalk.

Note: As the head and tail ends fold ventrally,

✓ Portions of the yolk sac are incorporated into the embryo.

✓ These incorporated parts form:

Foregut (cranial folding)

Hindgut (caudal folding)

✓ The remaining yolk sac lies outside the embryo.

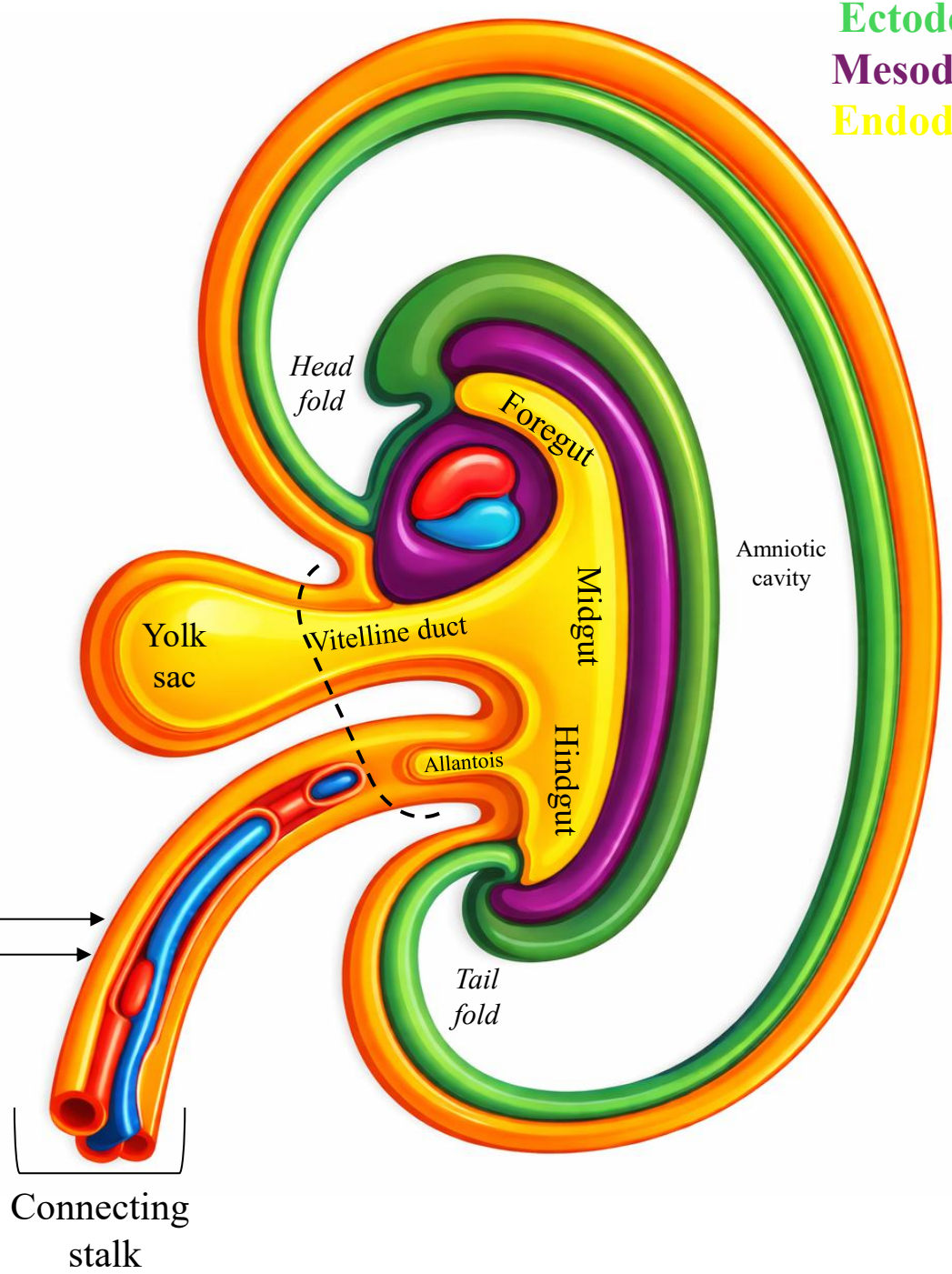
The gut tube is divided into:

- Foregut
- Midgut (still connected to yolk sac)
- Hindgut

Primitive umbilical ring is the opening in the ventral body wall where the connecting stalk, yolk sac (vitelline duct), and umbilical vessels pass between the embryo and the extraembryonic structures.

Remember: The **connecting stalk** is initially made of **extraembryonic mesoderm**.

The mesoderm of the connecting stalk differentiates to form the umbilical blood vessels (two arteries and one vein).



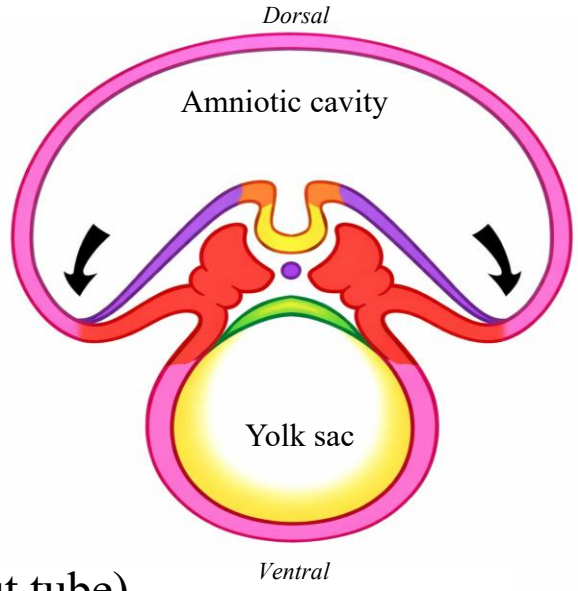
Transverse (Lateral) Folding

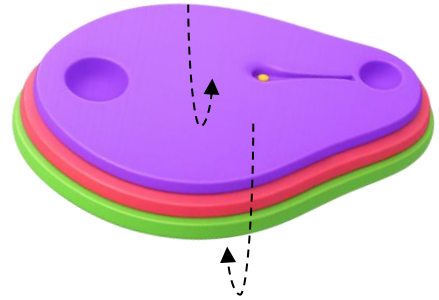
Lateral folding occurs on both sides of the embryo simultaneously (Occurs in the right-to-left direction)

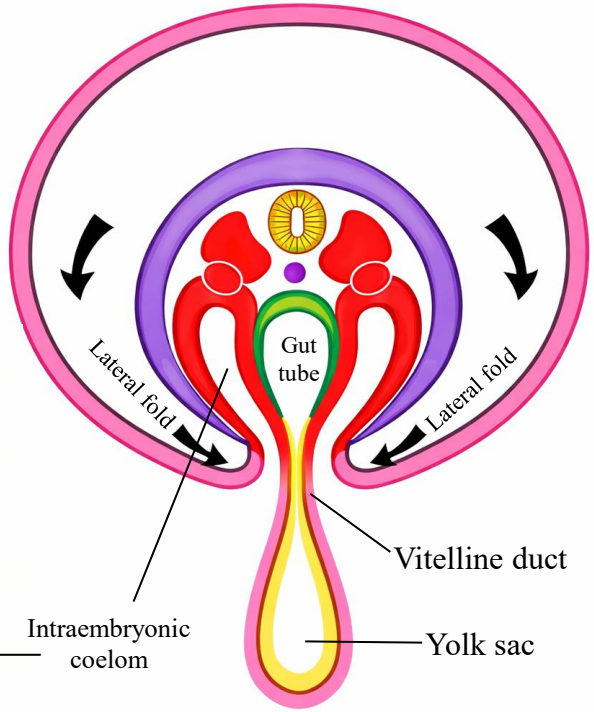
- ✓ Right and left sides of the embryonic disc move ventrally
- ✓ The lateral body folds approach each other in the midline
- ✓ The ventral body wall closes, except at the umbilical region

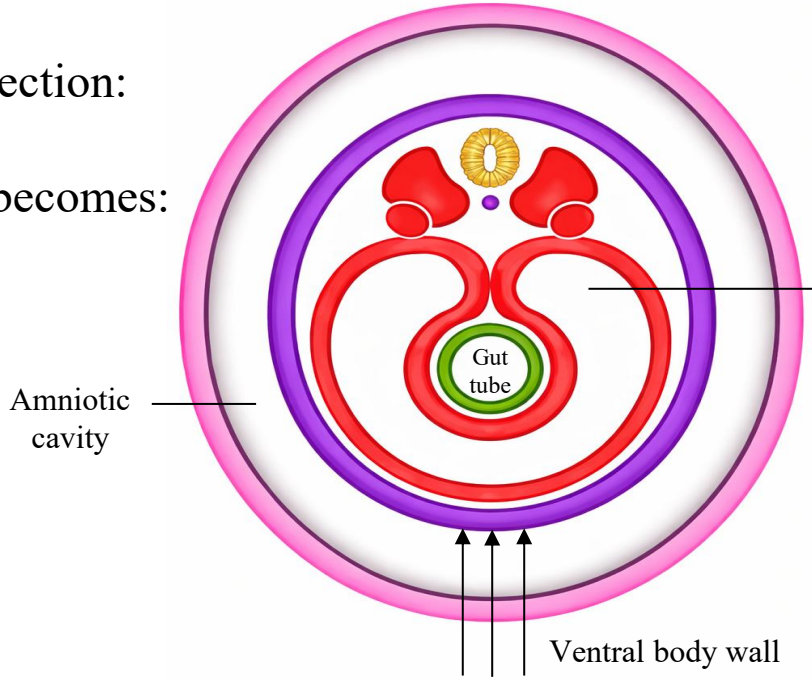
Results

- ✓ Formation of the gut tube (endoderm is enclosed to form the gut tube)
  - **Foregut**
  - **Midgut**
  - **Hindgut**
- ✓ The yolk sac is pinched off, leaving a narrow connection:
  - **Vitelline duct**
- ✓ Formation of the **intraembryonic coelom**, which becomes:
  - Pericardial cavity
  - Pleural cavities
  - Peritoneal cavity
- ✓ The embryo becomes cylindrical









Ectoderm
Mesoderm
Endoderm

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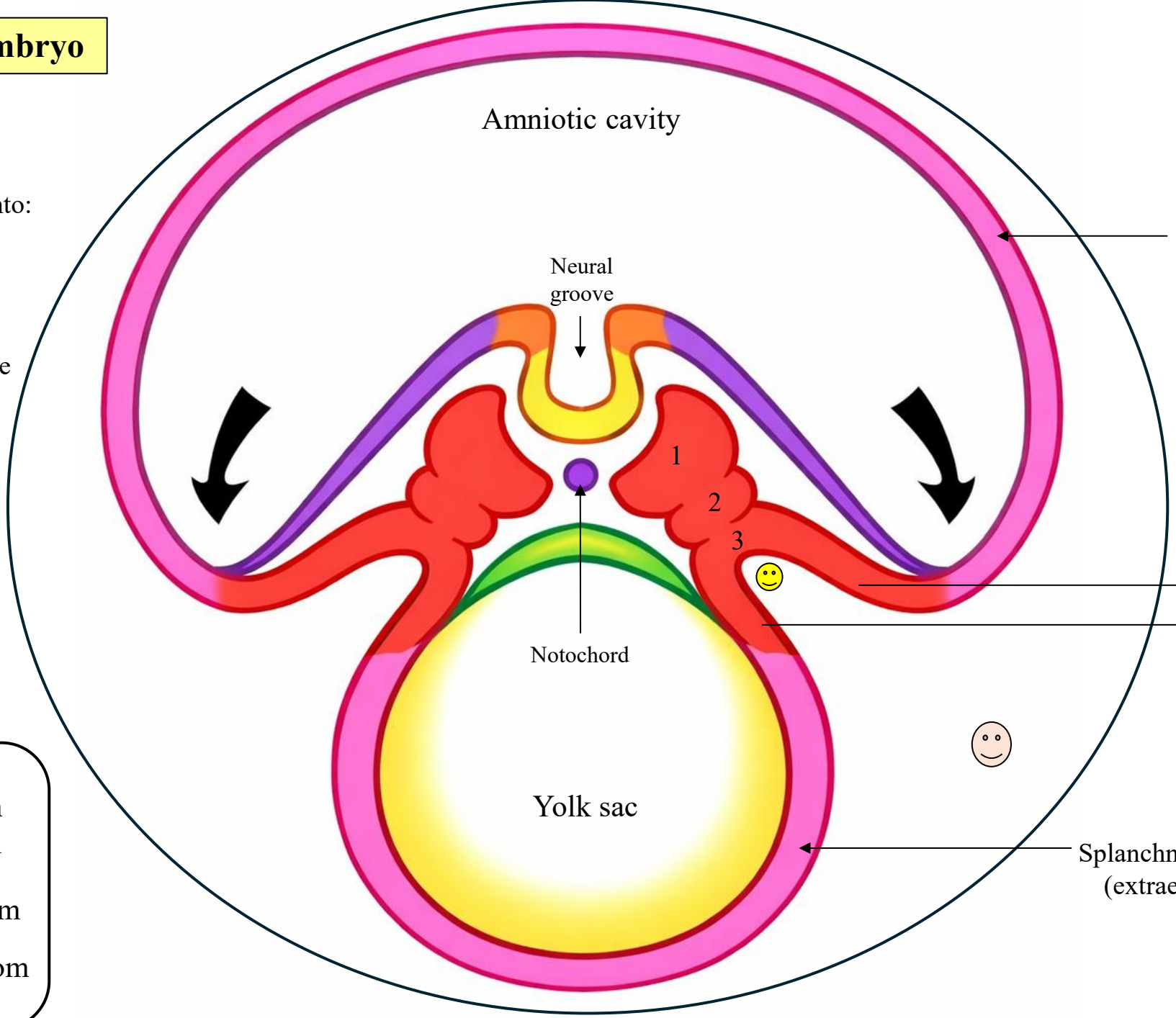
Cross section of the embryo

Ectoderm
Mesoderm
Endoderm

Remember:
Lateral plate mesoderm splits into:
Somatic (parietal) layer
Splanchnic (visceral) layer

Space between them forms the **intraembryonic coelom**



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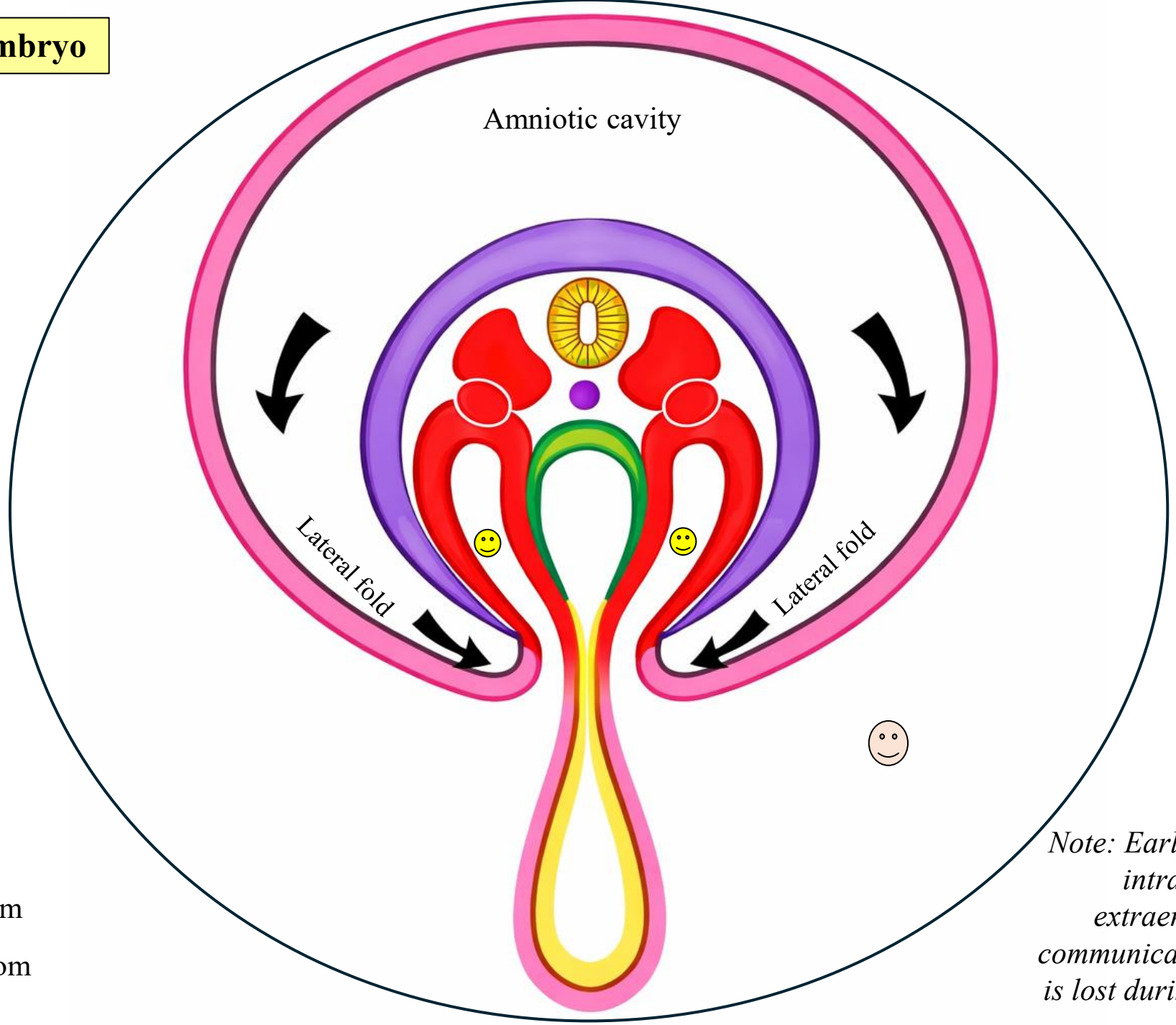
1- Paraxial mesoderm
2- Intermediate mesoderm
3- Lateral plate mesoderm

Intra-embryonic coelom

Extra-embryonic coelom (chorionic cavity)

Cross section of the embryo

Ectoderm
Mesoderm
Endoderm



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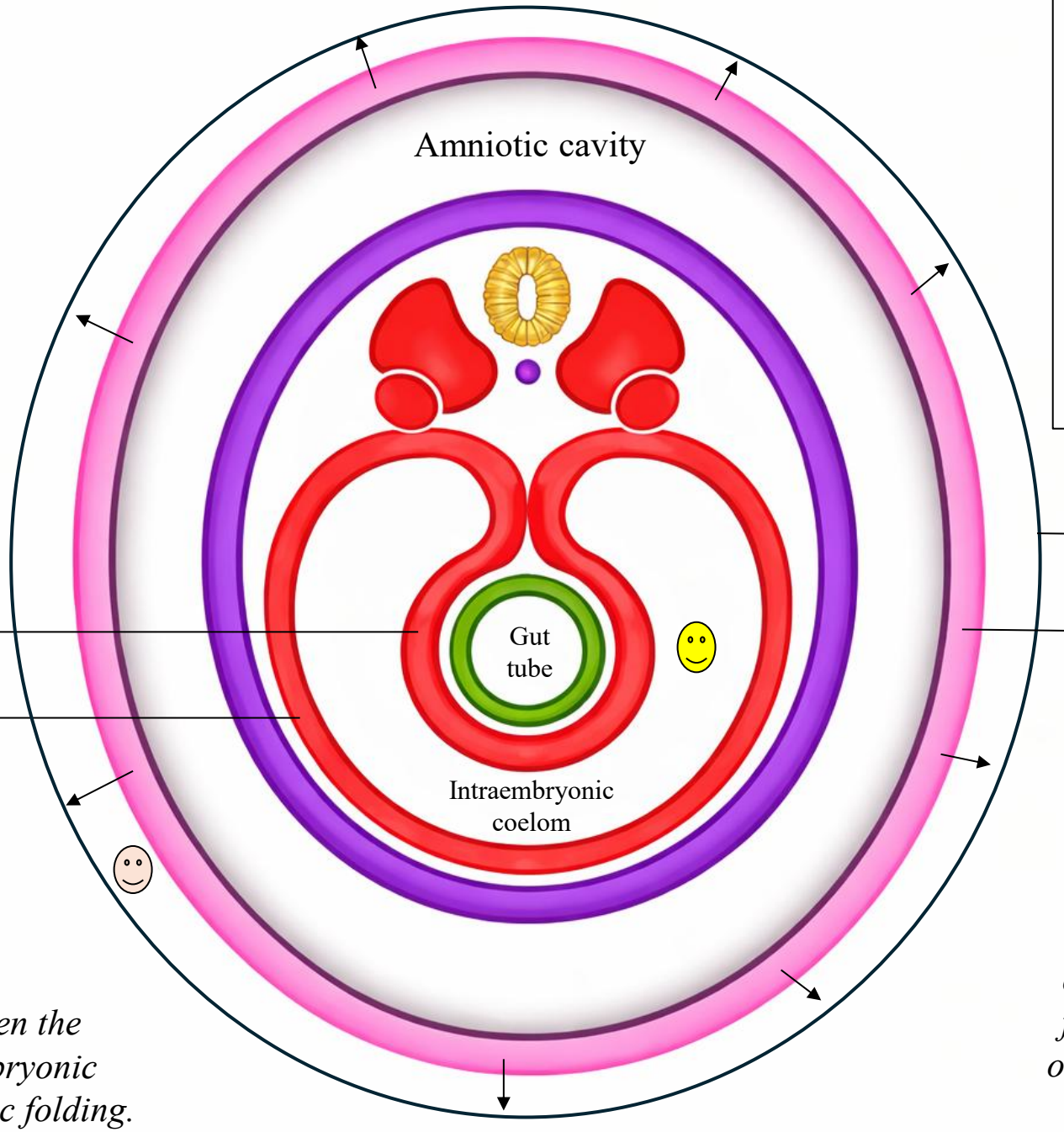
Intra-embryonic coelom

Extra-embryonic coelom
(chorionic cavity)

Note: Early in development, the intraembryonic and extraembryonic coeloms communicate, but this connection is lost during embryonic folding.

Cross section of the embryo

Ectoderm
Mesoderm
Endoderm



Splanchnic mesoderm (intraembryonic)

Somatic mesoderm (intraembryonic)

Chorion

Amnion

Fate of the Intraembryonic Coelom

The intraembryonic coelom gives rise to:

- Pericardial cavity
- Pleural cavities
- Peritoneal cavity

↓ ↓ ↓

Folding reorganizes body spaces

Note: Rapid expansion of the amniotic cavity compresses the chorionic cavity until the amnion fuses with the chorion, leading to obliteration of the chorionic cavity. (amniochorionic membrane)

Note: The connection between the intraembryonic and extraembryonic coeloms is lost during embryonic folding.

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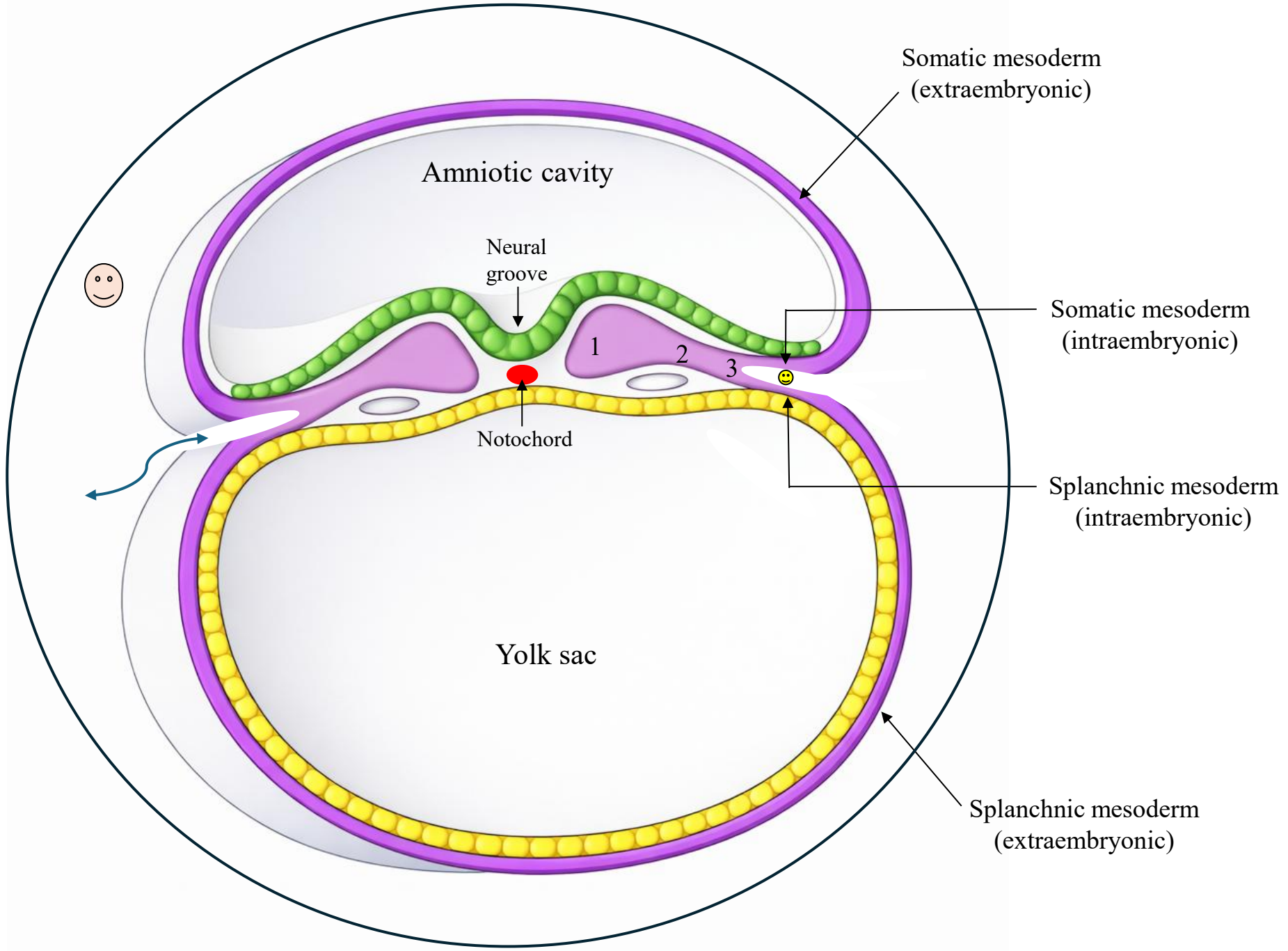

Ectoderm
Mesoderm
Endoderm

1- Paraxial mesoderm
2- Intermediate mesoderm
3- Lateral plate mesoderm

Intra-embryonic coelom

Extra-embryonic coelom
(chorionic cavity)

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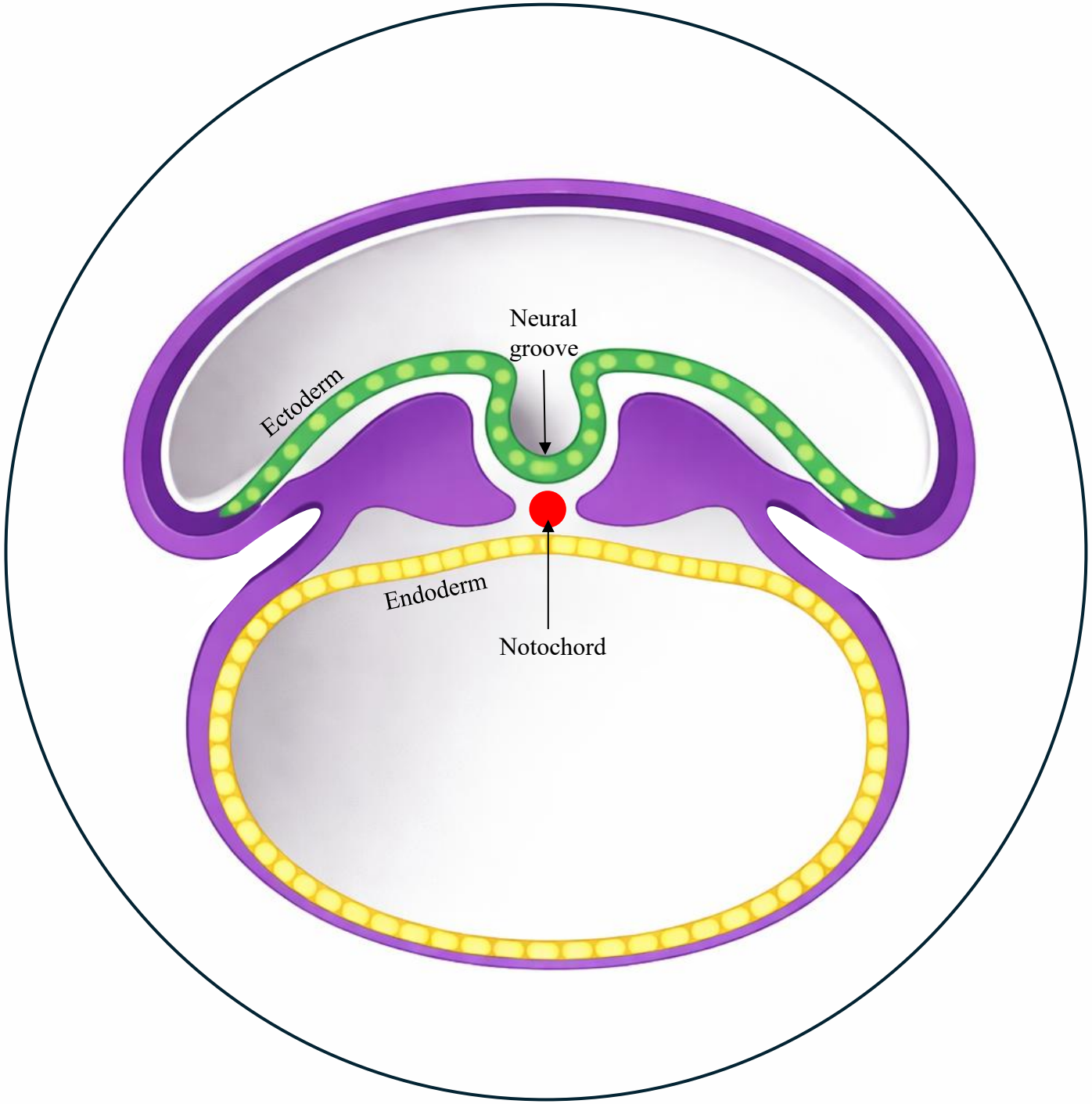

Ectoderm
Mesoderm
Endoderm

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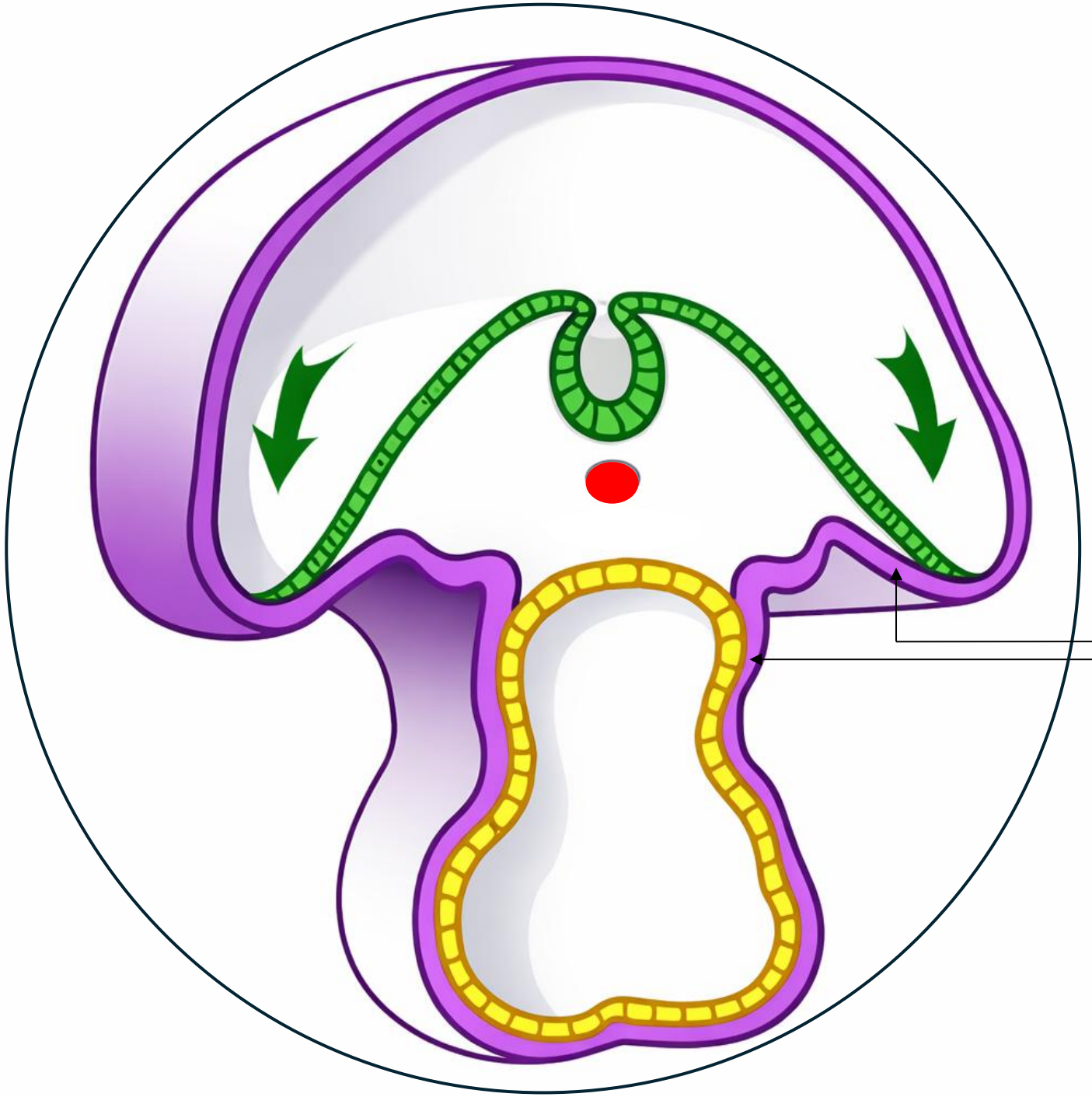

Ectoderm
Mesoderm
Endoderm

Cross section at the level of midgut

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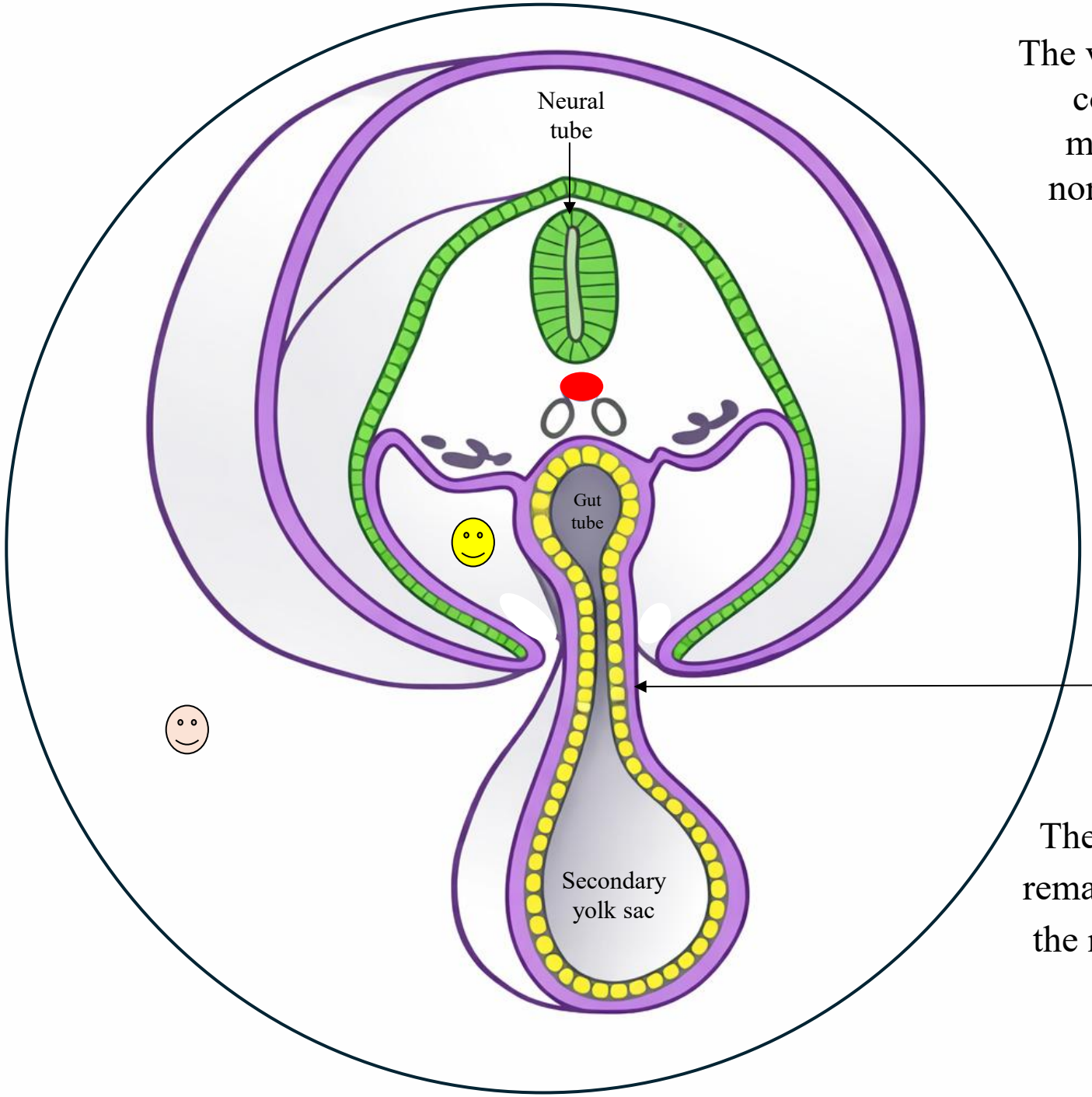

The vitelline duct is a transient connection between the midgut and yolk sac that normally obliterates by the end of the 7th week.

The yolk sac is pinched off and remains temporarily connected to the midgut by a narrow vitelline duct.

Intra-embryonic coelom

Extra-embryonic coelom (chorionic cavity)

The intraembryonic coelom later subdivides into:

- ✓ Pericardial cavity
- ✓ Pleural cavities
- ✓ Peritoneal cavity

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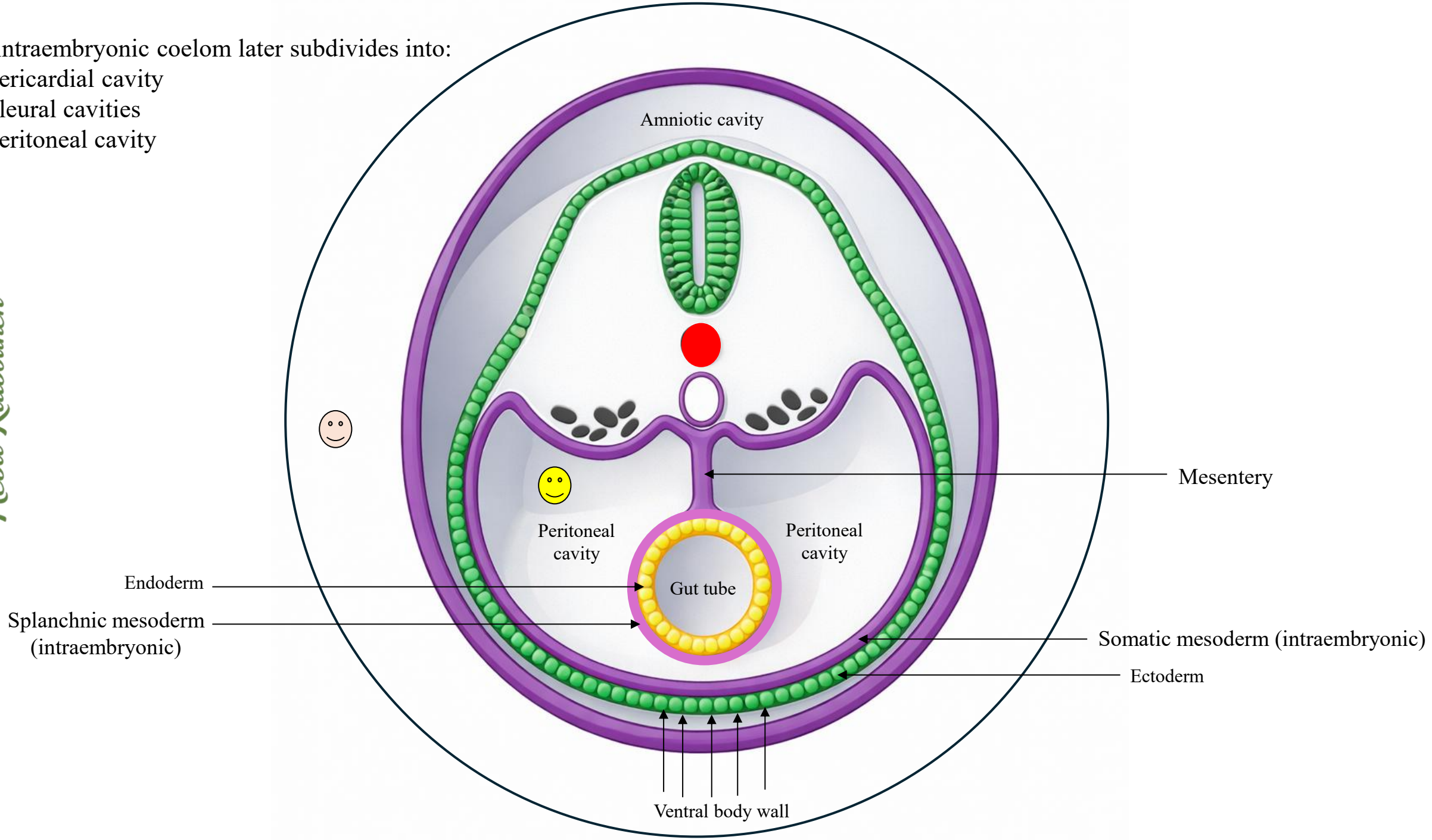
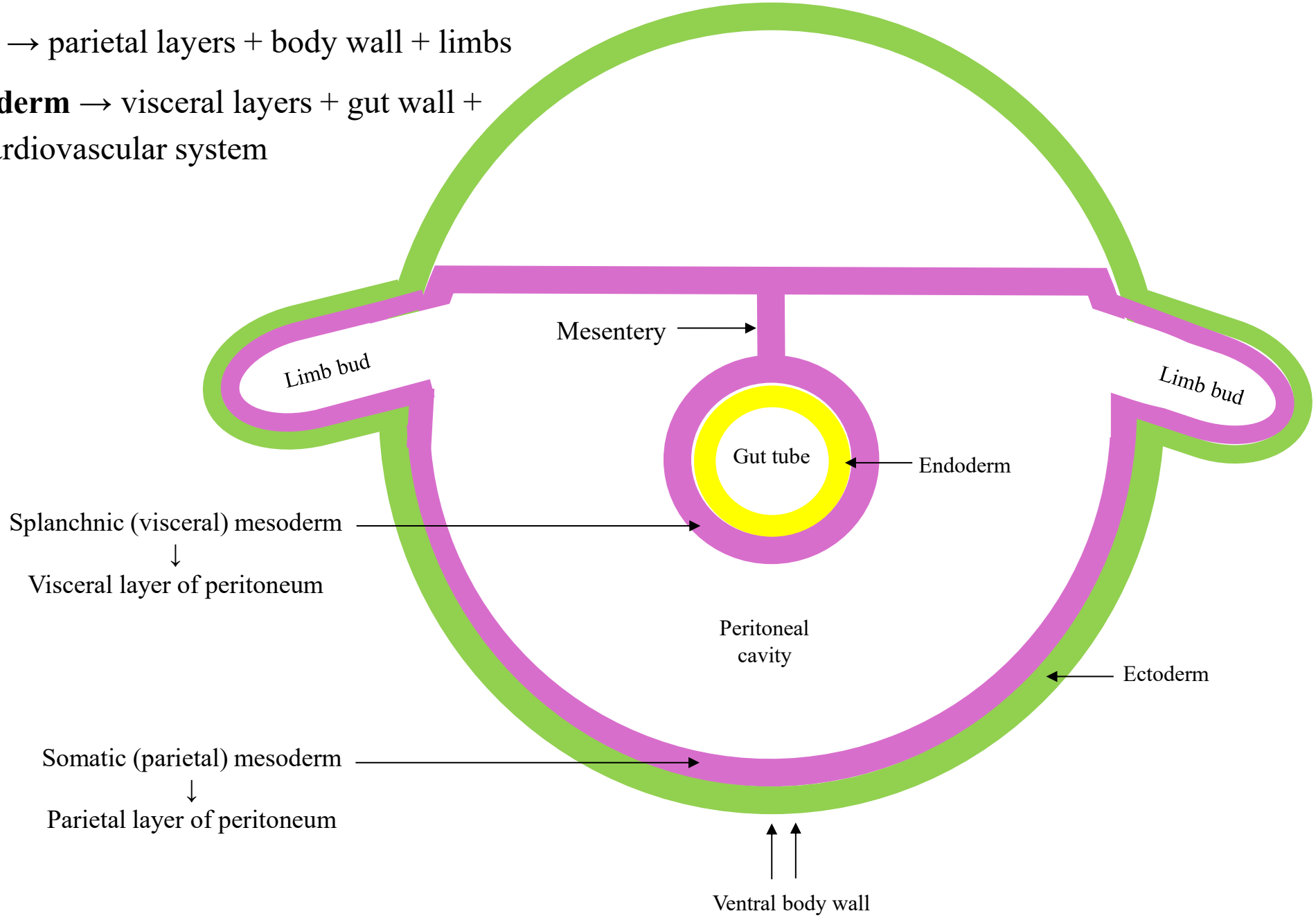


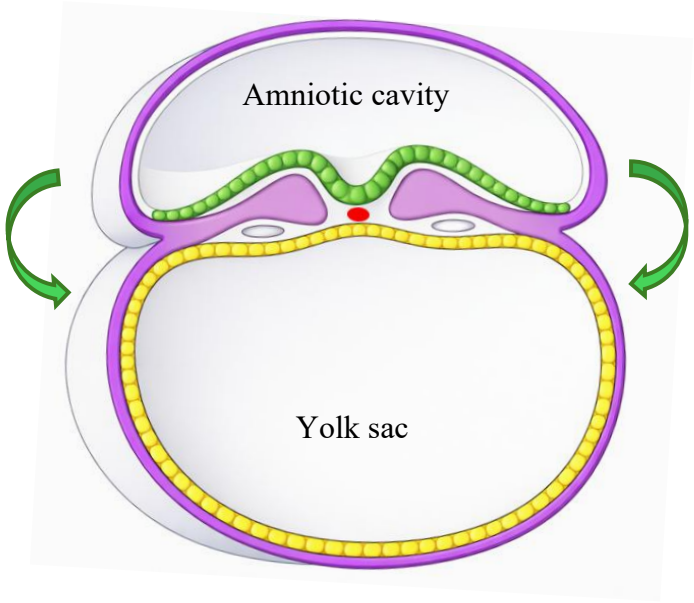
Note:

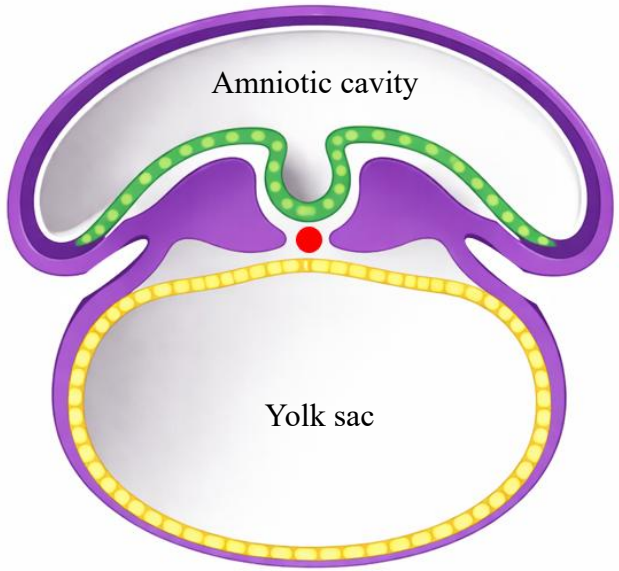
Somatic mesoderm → parietal layers + body wall + limbs

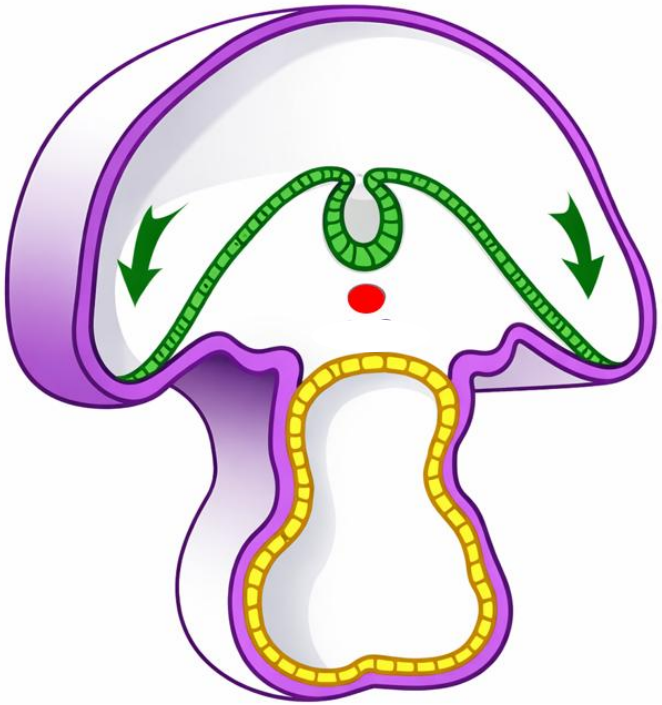
Splanchnic mesoderm → visceral layers + gut wall + cardiovascular system

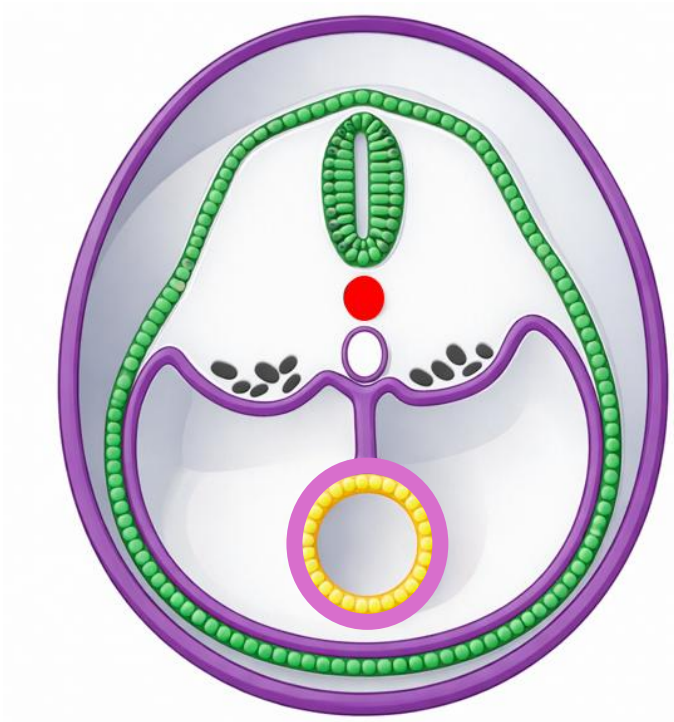


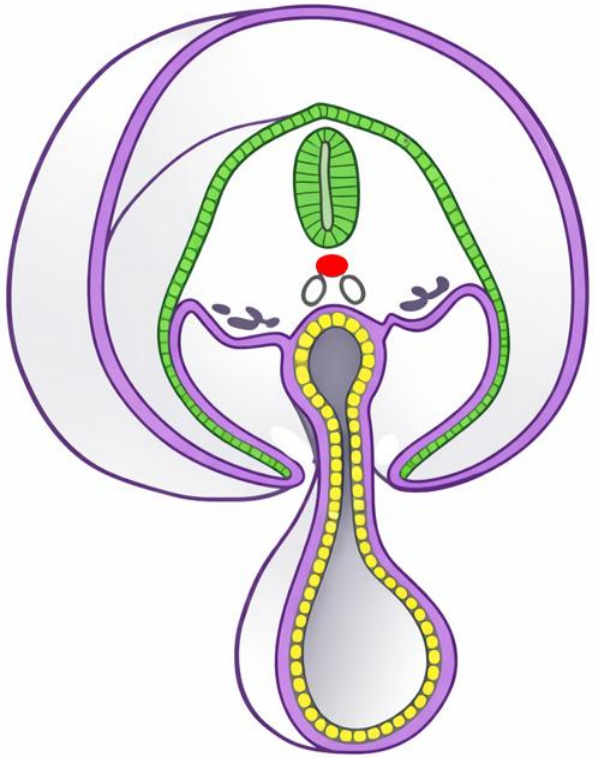
Ectoderm
Mesoderm
Endoderm







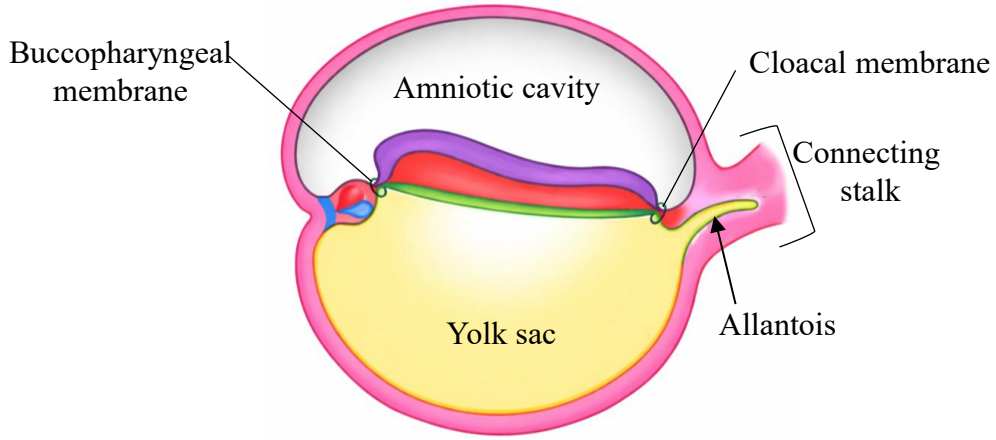


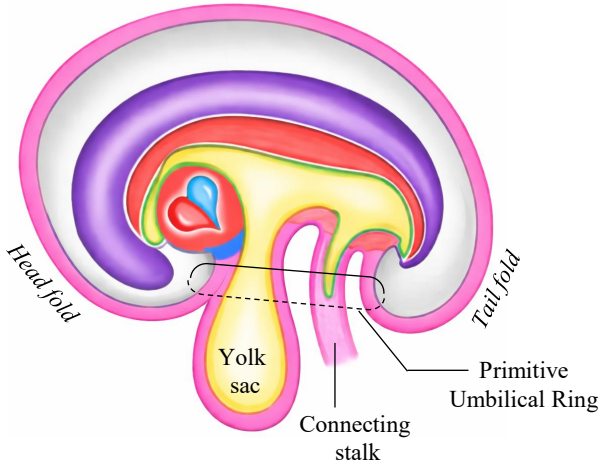


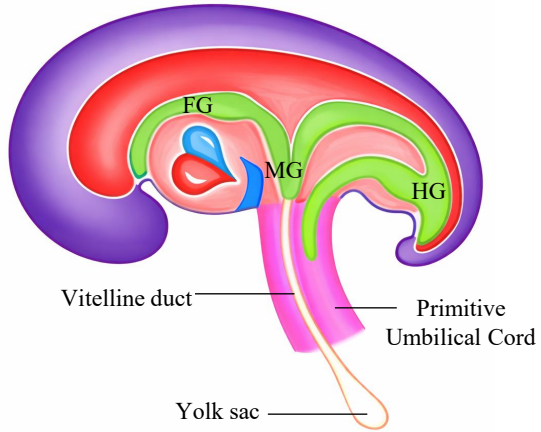
Ectoderm
Mesoderm
Endoderm

Ectoderm
Mesoderm
Endoderm

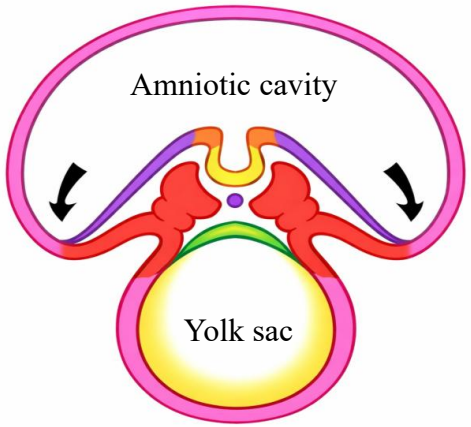
Sagittal sections of the embryo

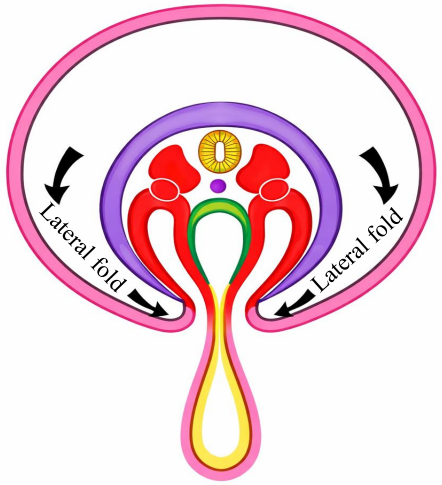


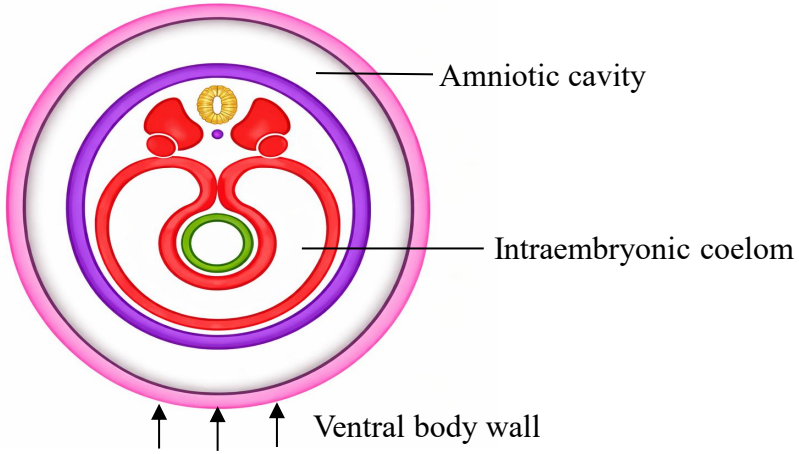




Cross sections of the embryo







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Combined Effects of Embryonic Folding

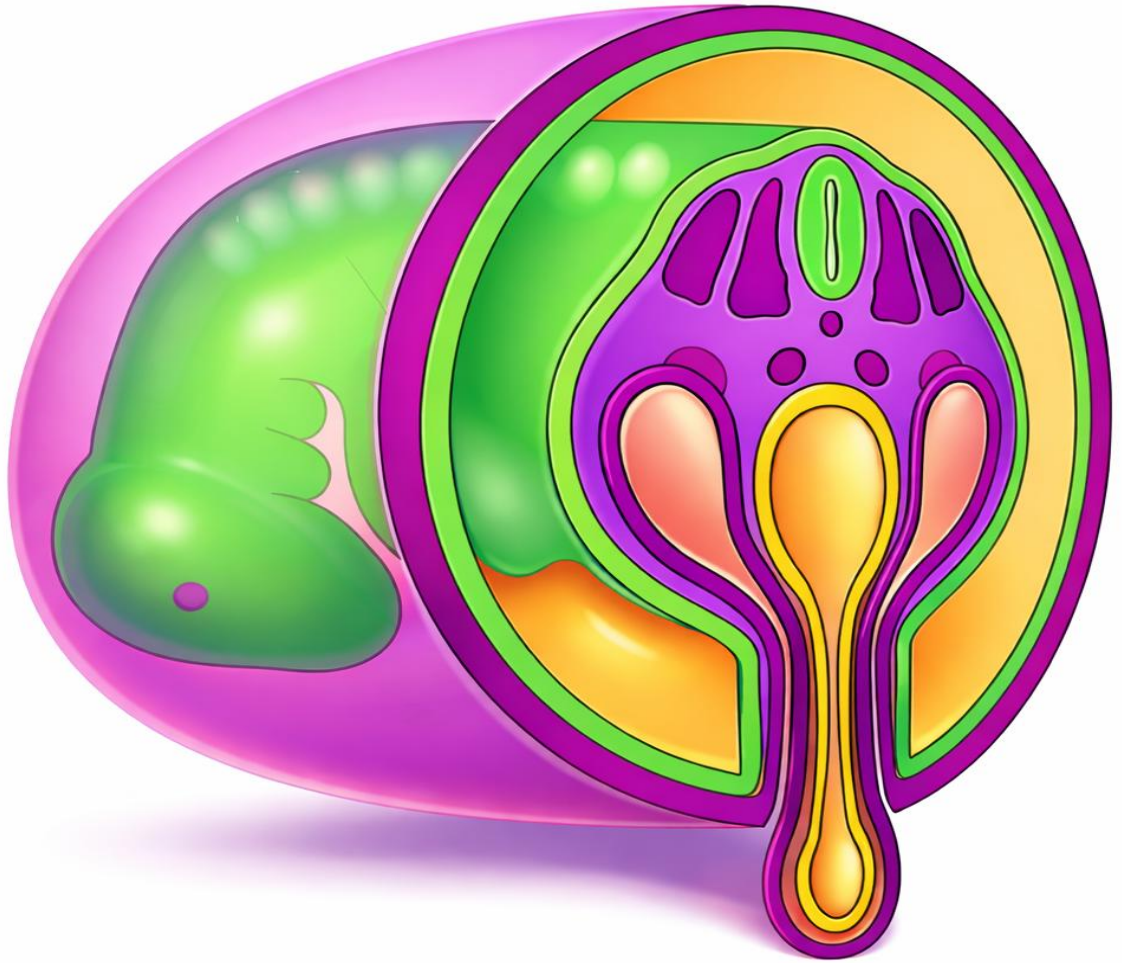
As craniocaudal and lateral folding occur simultaneously:

- The flat disc → tube-within-a-tube body plan
- Endoderm → gut tube
- Mesoderm → body wall, muscles, skeleton, coelomic cavities
- Ectoderm → neural tube and skin
- The primitive umbilical ring forms
- Extraembryonic structures are brought together to form the primitive umbilical cord

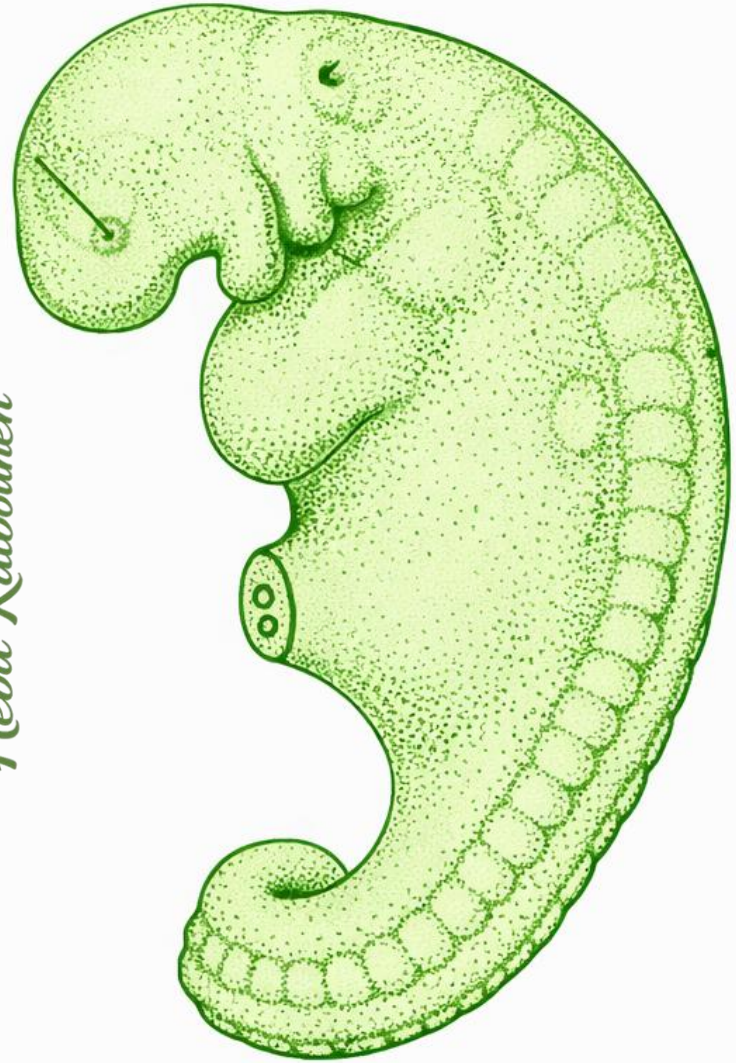
Key Outcomes of Embryonic Folding

- Formation of the foregut, midgut, and hindgut
- Closure of the ventral body wall
- Establishment of the umbilical region
- Positioning of the heart in the thorax
- Transformation into a 3D embryo

Ectoderm
Mesoderm
Endoderm



28 days



Lateral view