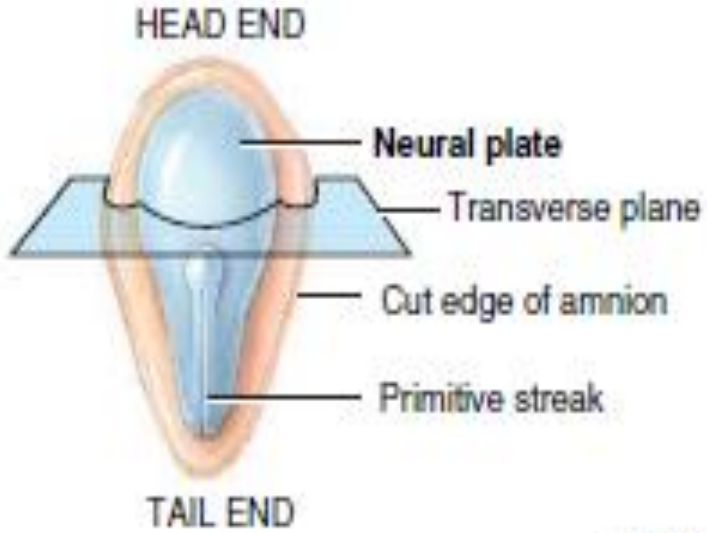
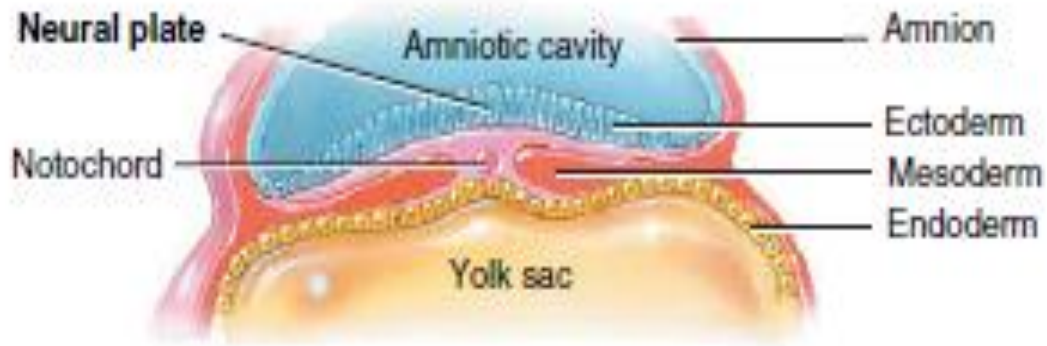
Third week of development part2

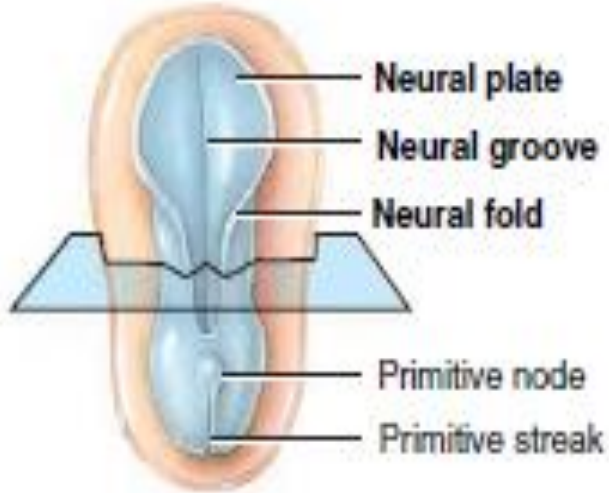
D. Chikwanda

- **NEURULATION: FORMATION OF THE NEURAL TUBE**
- processes involved in the formation of the neural plate and neural folds and closure of the folds to form the **neural tube** constitute **neurulation**
- completed by the end of the fourth week, when closure of the caudal **neuropore** occurs
- As the **notochord** develops, it **induces** the overlying embryonic ectoderm located at or adjacent to the midline to thicken
- Form an elongated plate of thickened epithelial cells called the **neural plate**
- ectoderm of the neural plate (neuroectoderm) gives rise to the **CNS**-the brain and spinal cord

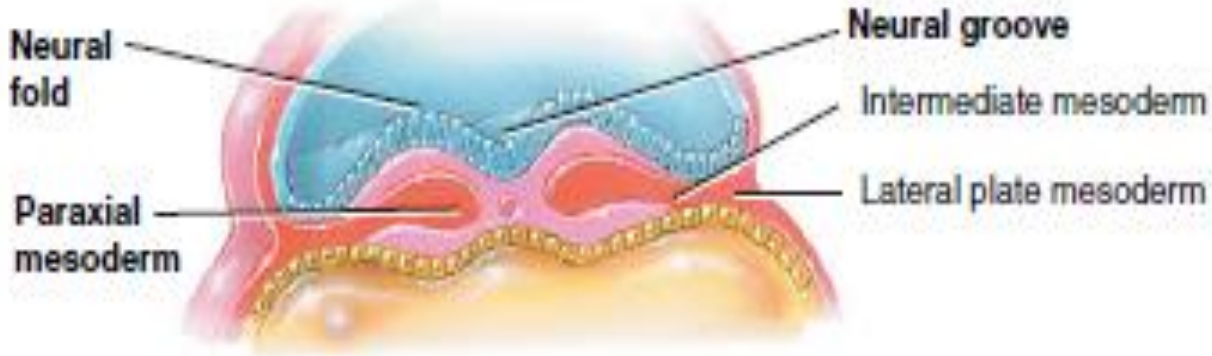


(a) 17 days





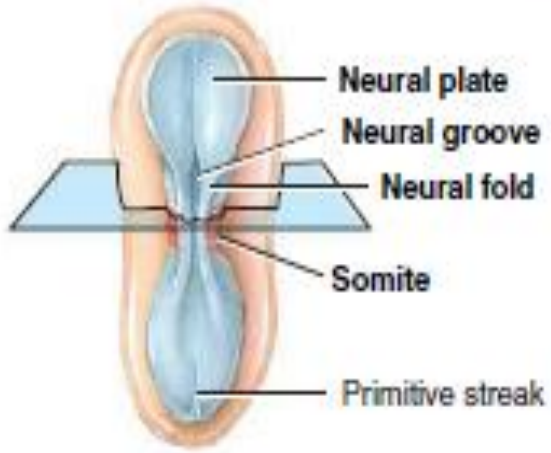
(b) 19 days

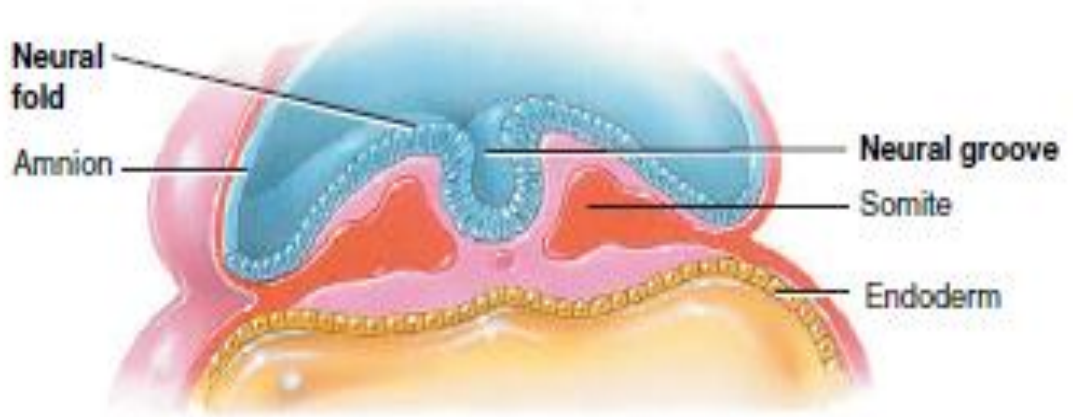


- Initially the elongated neural plate corresponds in length to the underlying notochord
- appears rostral to the primitive node and dorsal to the notochord and the mesoderm adjacent to it
- the notochord elongates, the neural plate broadens and eventually extends cranially as far as the oropharyngeal membrane
- Eventually the neural plate extends beyond the notochord

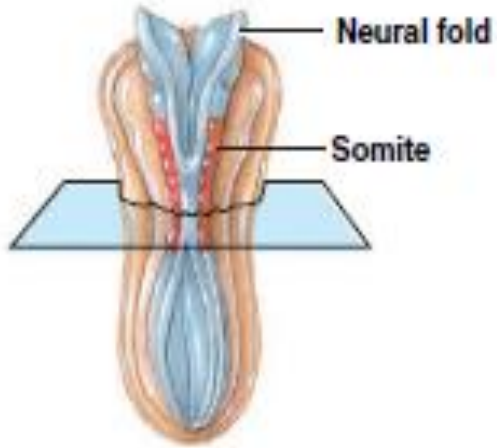
- On the 18th day, the neural plate invaginates along its central axis to form a longitudinal median **neural groove**, which has neural folds on each side
- **neural folds** become prominent at the cranial end of the embryo and are the first signs of brain development
- end of the third week, the neural folds have begun to move together and fuse
- converting the neural plate into a **neural tube**, the primordium of the CNS
- neural tube soon separates from the surface ectoderm as the neural folds meet

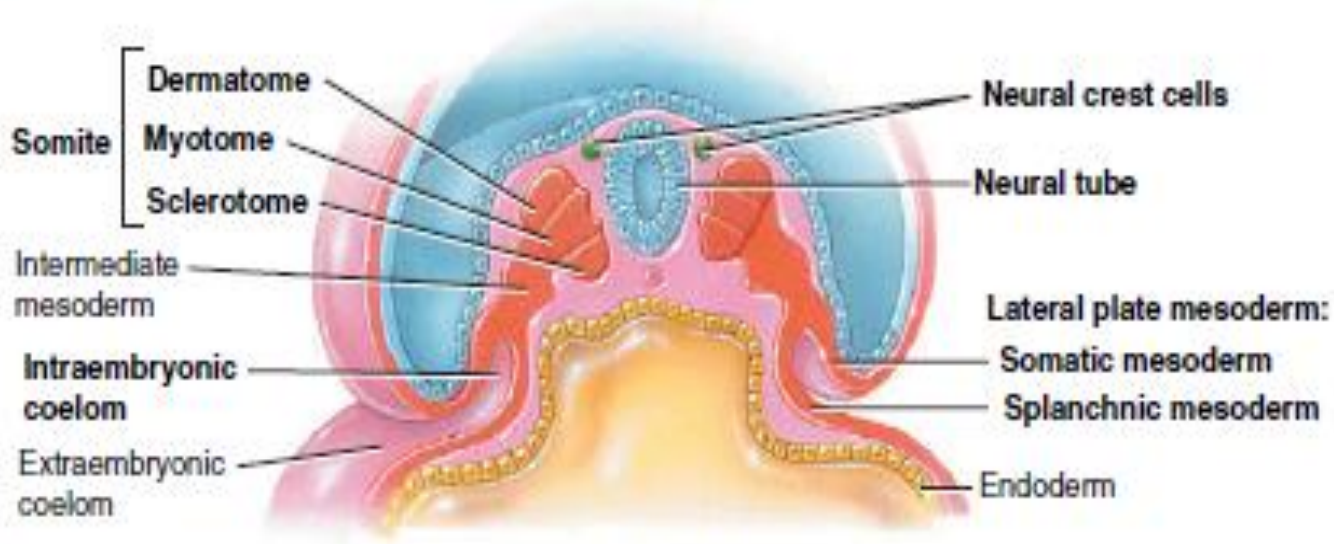
(b) 19 days





(c) 20 days





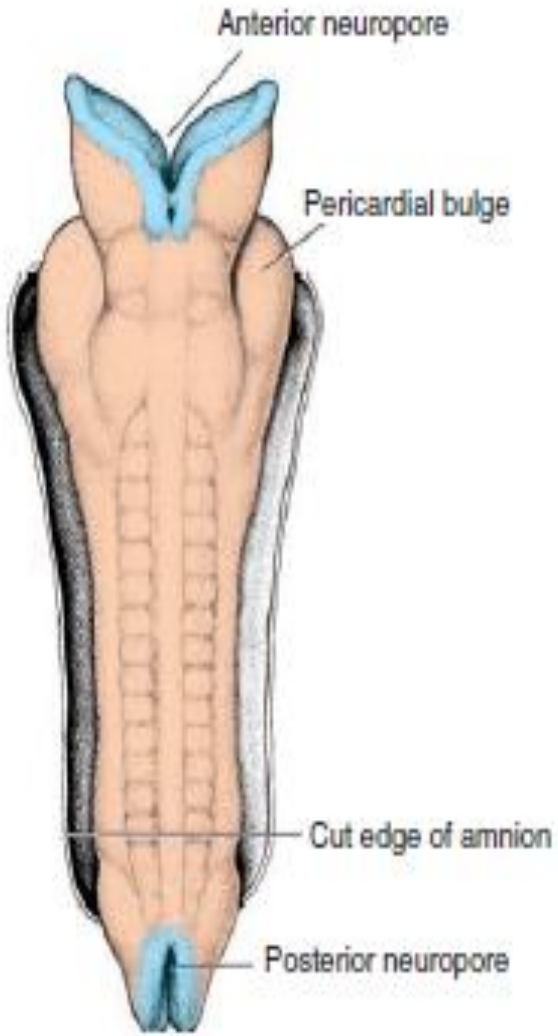
Dorsal views

(d) 22 days

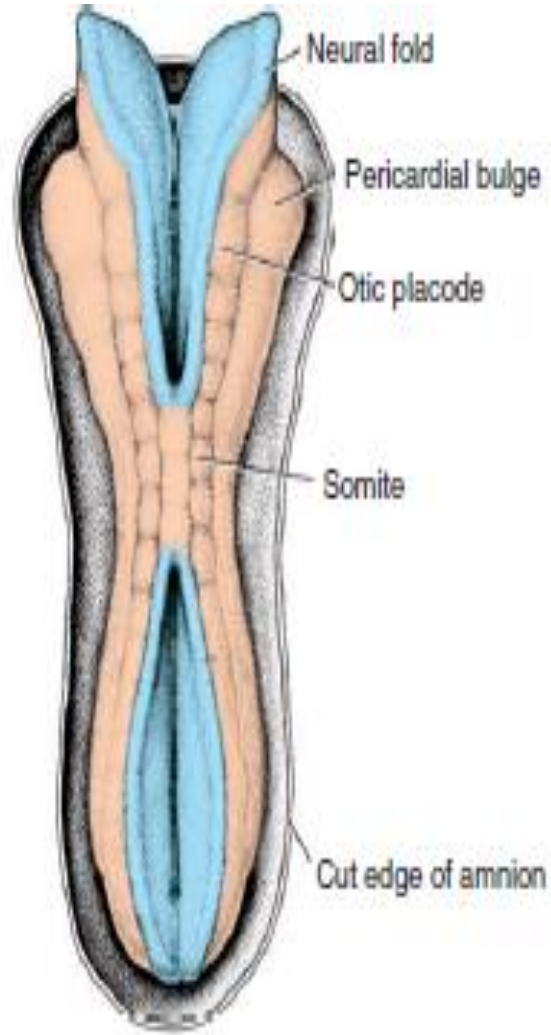
Transverse sections

- free edges of the surface ectoderm (non-neural ectoderm) fuse so that this layer becomes continuous over the neural tube and the back of the embryo
- surface ectoderm differentiates into the epidermis


Anterior ne
Posterior n
D
23 days

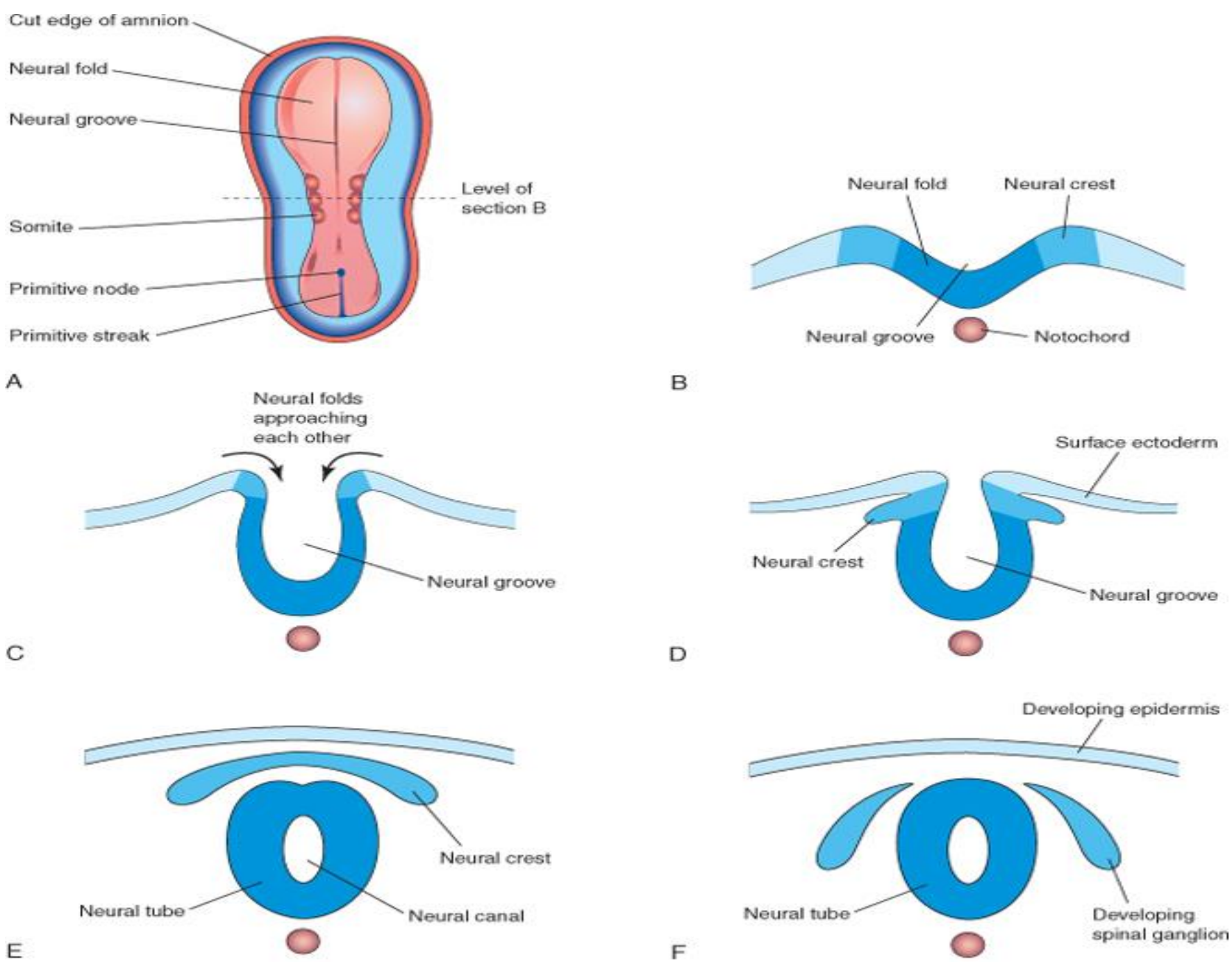

Anterior neuropore
Pericardial bulge
Cut edge of amnion
Posterior neuropore
23 days

C


Neural fold
Pericardial bulge
Otic placode
Somite
Cut edge of amnion
A
22 days


Neural fold
Somites
B
22 days

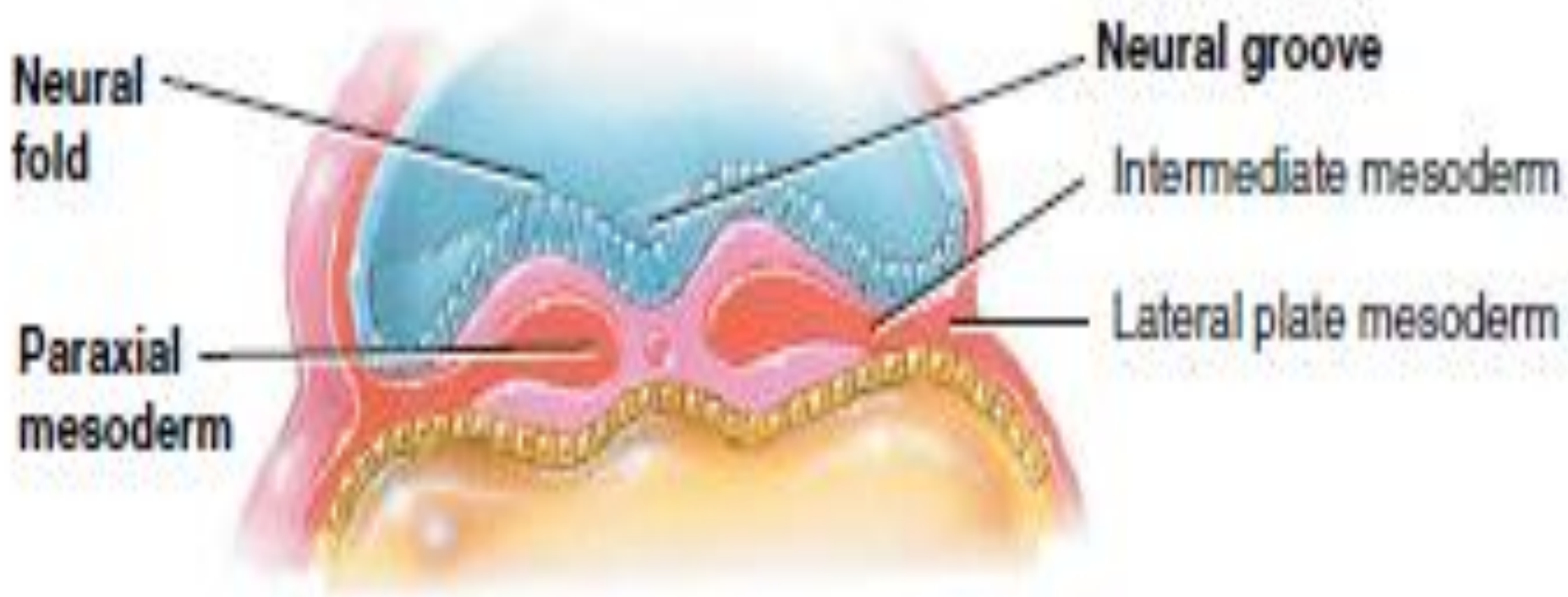
- **Neural Crest Formation**
- As the neural folds fuse to form the neural tube, some neuroectodermal cells lying along the inner margin of each neural fold lose their epithelial affinities and attachments to neighboring cells
- As the neural tube separates from the surface ectoderm, **neural crest cells** form a flattened irregular mass, the **neural crest**
- Found between the neural tube and the overlying surface ectoderm

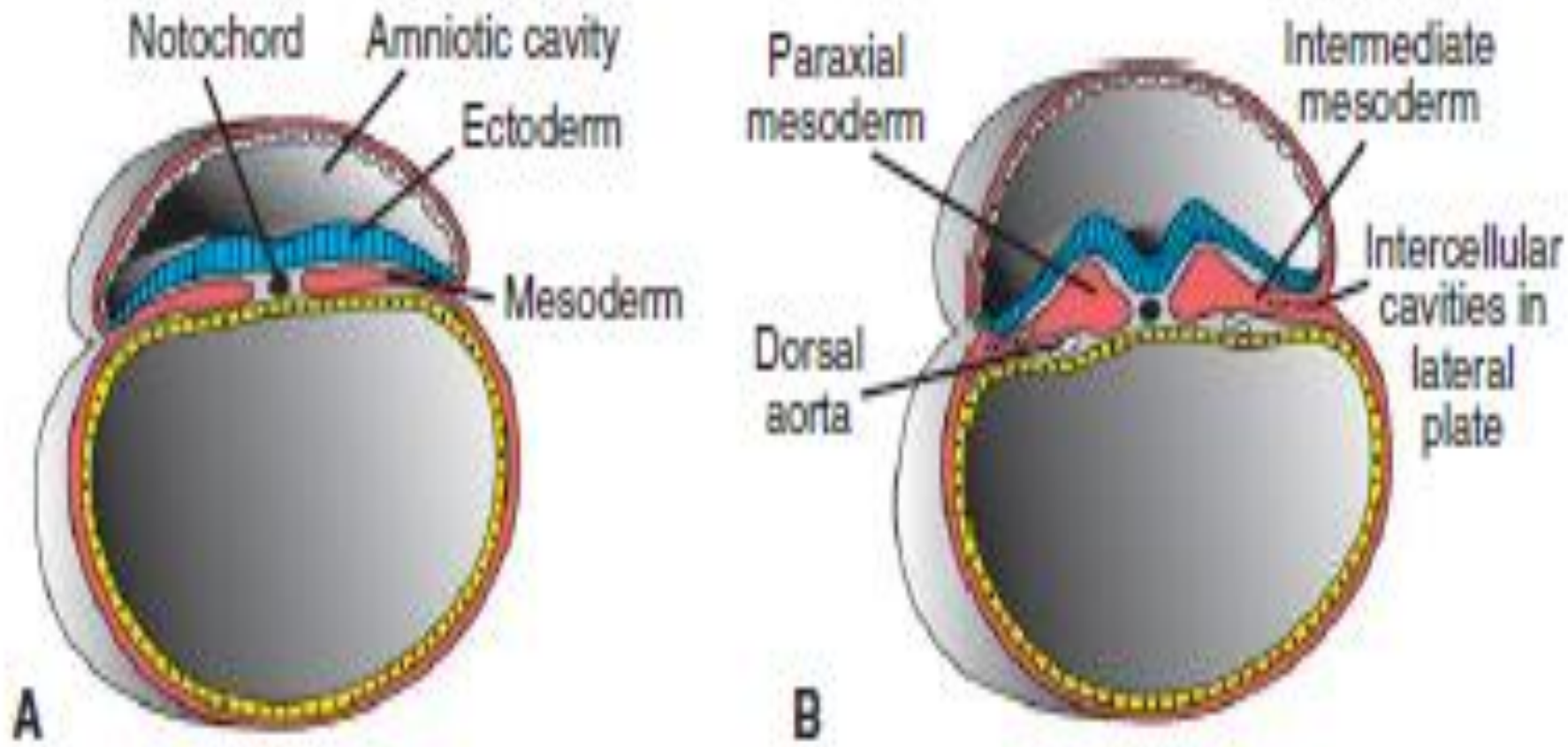


- neural crest soon separates into right and left parts that shift to the dorsolateral aspects of the neural tube
- they give rise to the **sensory ganglia of the spinal and cranial nerves**
- Neural crest cells subsequently move both into and over the surface of somites

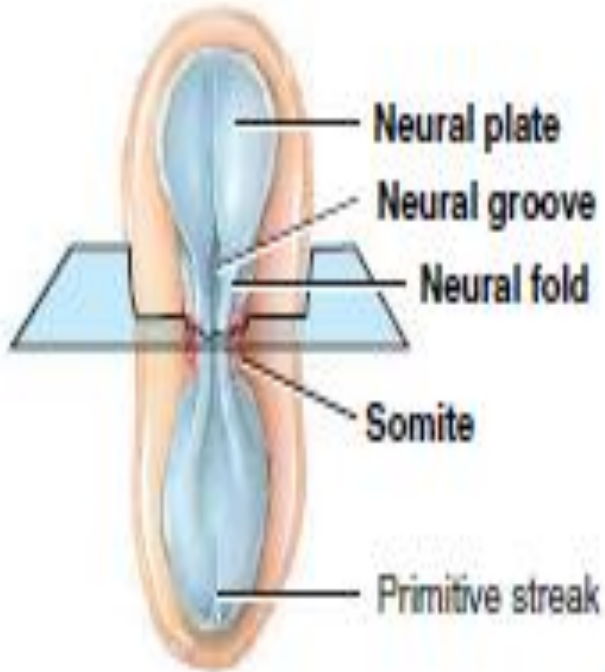
- Neural crest cells give rise to the:-
- spinal ganglia (dorsal root ganglia) and the ganglia of the autonomic nervous system
- ganglia of cranial nerves V, VII, IX, and X
- form ganglion cells,
- the neurolemma sheaths of peripheral nerves and contribute to the formation of the leptomeninges
- form pigment cells(melanocytes), the suprarenal (adrenal) medulla, and many connective tissue components in the head

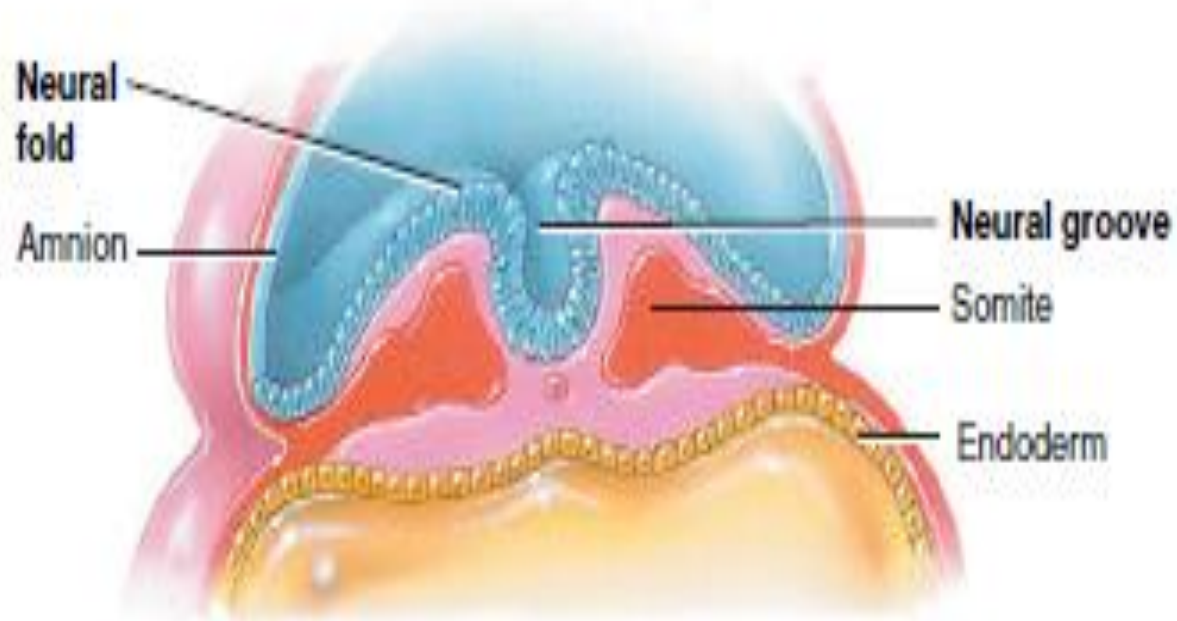
- **SUBDIVISIONS OF INTRAEMBRYONIC MESODERM**
- By about the seventeenth day after fertilization
- the mesoderm adjacent to the notochord and neural tube forms paired longitudinal columns of **paraxial mesoderm**
- the mesoderm lateral to the paraxial mesoderm forms paired cylindrical masses called **intermediate mesoderm**.
- the mesoderm lateral to the intermediate mesoderm consists of a pair of flattened sheets called **lateral plate mesoderm**


Neural fold
Neural groove
Intermediate mesoderm
Paraxial mesoderm
Lateral plate mesoderm

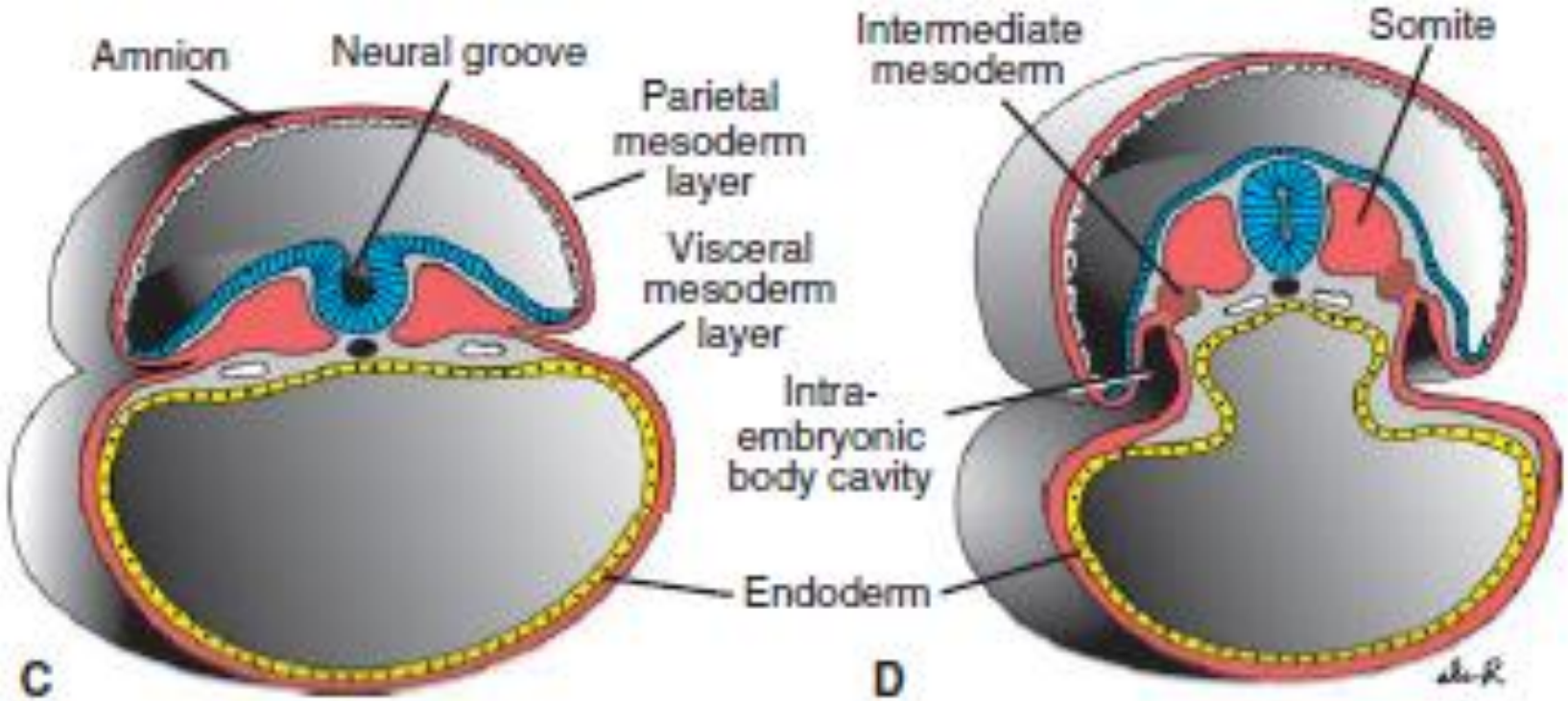

Notochord
Amniotic cavity
Ectoderm
Mesoderm
A
Paraxial mesoderm
Intermediate mesoderm
Intercellular cavities in lateral plate
Dorsal aorta
B

- Toward the end of the third week, the **paraxial mesoderm** differentiates, condenses, and begins to segment
- segments are of two categories:
- (1) somitomeres
- (2) somites
- ***Somitomeres*** lie in the region of the head
- They are rounded structures, are seven of them
- They form the mesoderm and muscles of the head and jaw


Neural plate
Neural groove
Neural fold
Somite
Primitive streak


Neural fold
Amnion
Neural groove
Somite
Endoderm

(c) 20 days


Amnion
Neural groove
Parietal mesoderm layer
Visceral mesoderm layer
Intra-embryonic body cavity
Endoderm
C
Intermediate mesoderm
Somite
D

- ***Somites*** are cubical and more distinctly segmented
- The most cranial somites are formed in the occipital region
- The first pair of somites appear at approximately 20th day of development
- New somites are progressively formed caudal to them appear 3 pairs of somites per day
- By the end of the fifth week there are about 44 pairs of somites (4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 8–10 coccygeal)

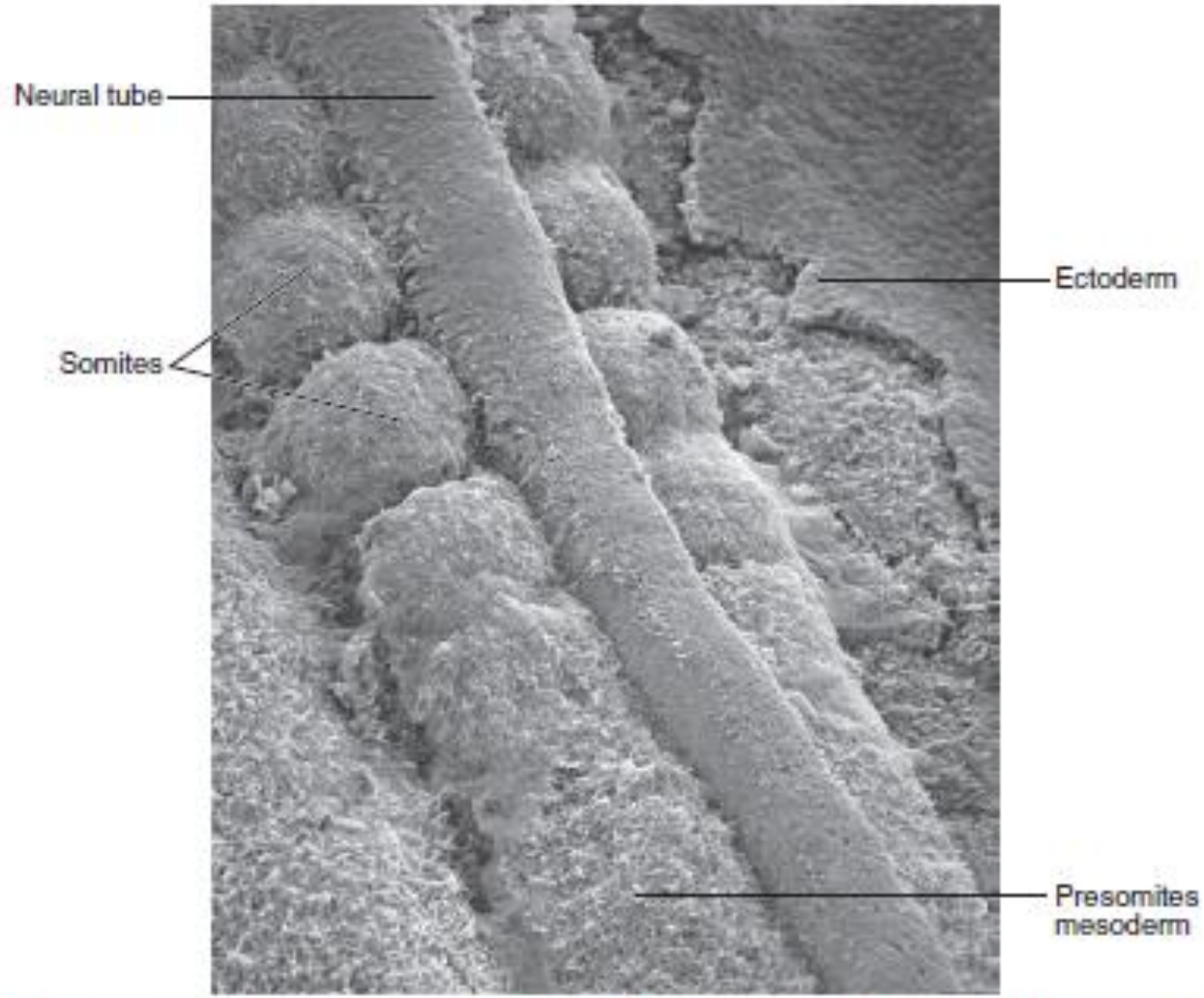


Figure 6.10 Dorsal view of somites forming along the neural tube (the ectoderm has been partially removed). Somites form from unsegmented presomitic paraxial mesoderm caudally and become segmented in more cranially positioned regions.

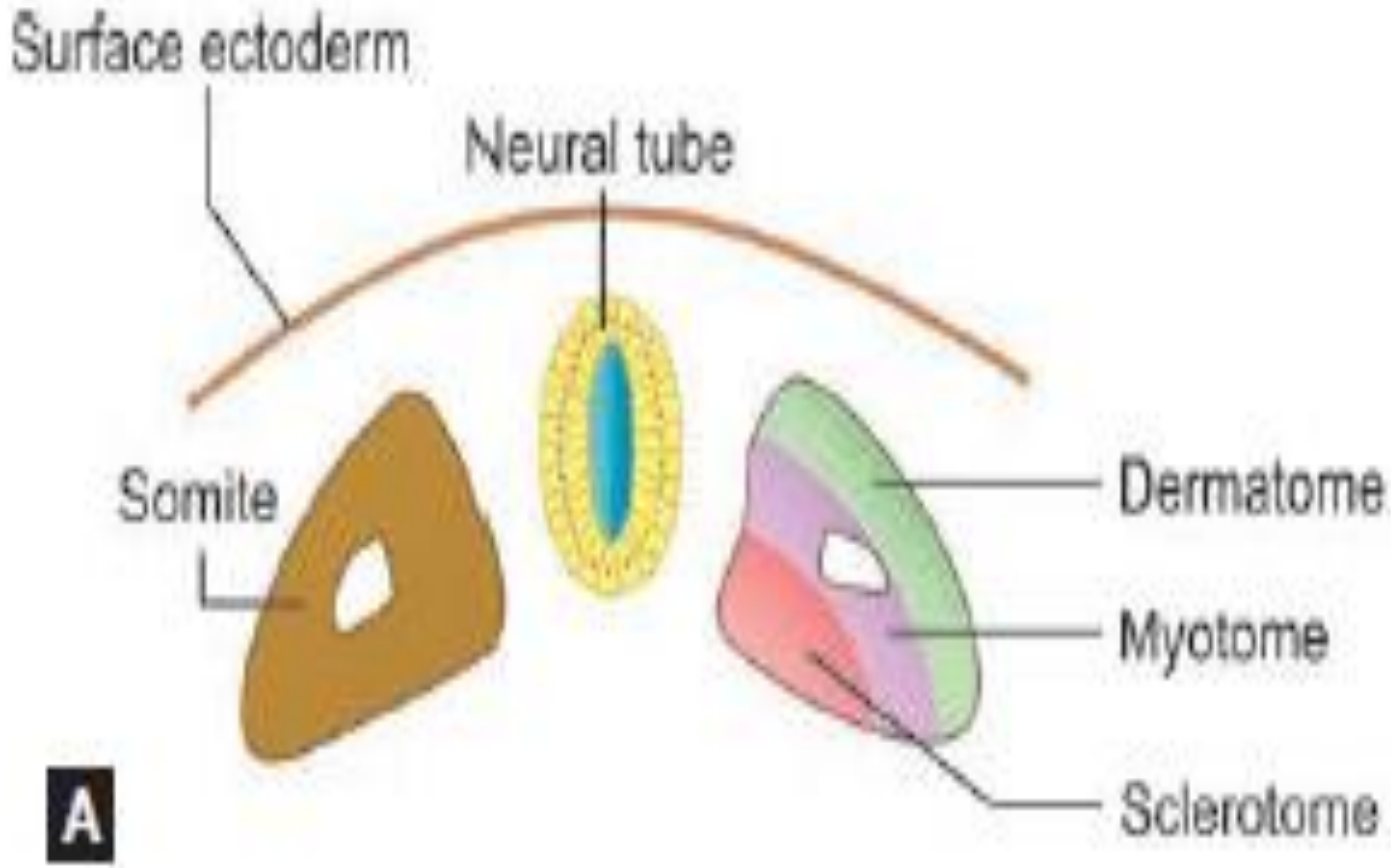
- Occipital somites form muscles of the tongue
- Somites form the axial skeleton, skeletal muscle and part of skin(dermis)
- somitomeres give origin to some mesenchyme
- somites are so prominent during the fourth and fifth weeks, they are used as one of several criteria for determining an embryo's age

TABLE 6.2 *Number of Somites Correlated to Approximate Age in Days*

Approximate Age (Days)	Number of Somites
20	1–4
21	4–7
22	7–10
23	10–13
24	13–17
25	17–20
26	20–23
27	23–26
28	26–29
30	34–35

- Each somite differentiates into two parts:-
- 1.ventromedial part is the **sclerotome**;
- its cells form the vertebrae and ribs

- 2.dorsolateral part is the **dermomyotome**;
- cells from its myotome region form myoblasts (primordial muscle cells)
- cells from its dermatome region form the dermis (fibroblasts).


Surface ectoderm
Neural tube
Somite
Dermatome
Myotome
Sclerotome
A

- **LATERAL PLATE MESODERM—FORMATION OF INTRAEMBRYONIC COELOM**
- small spaces appear in the lateral plate mesoderm
- These coalesce (come together) to form one large cavity, called the ***intraembryonic coelom***
- cavity has the shape of a horseshoe
- There are two halves of the cavity (one on either side of the midline) which are joined together cranial to the prochordal plate
- At first, this is a closed cavity but soon it comes to communicate with the extraembryonic coelom

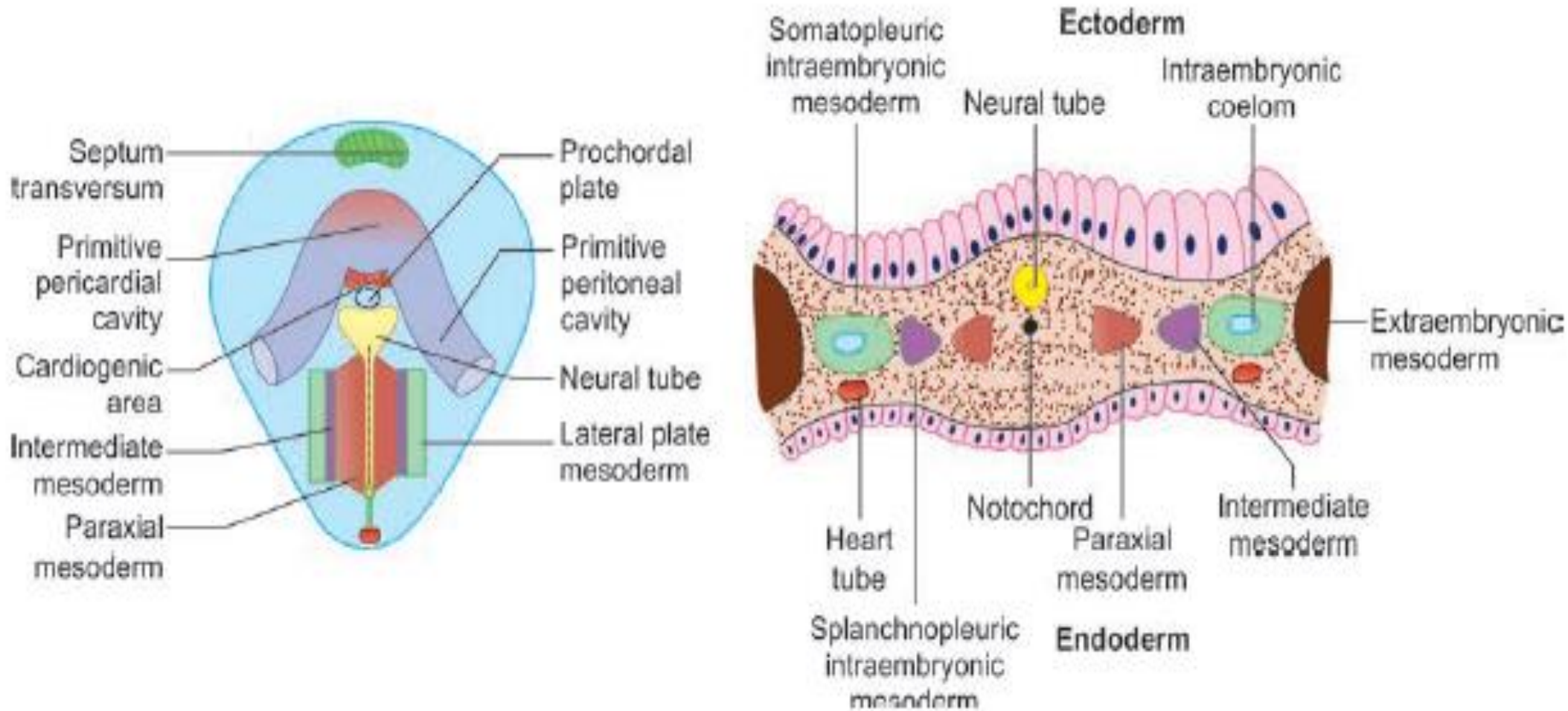
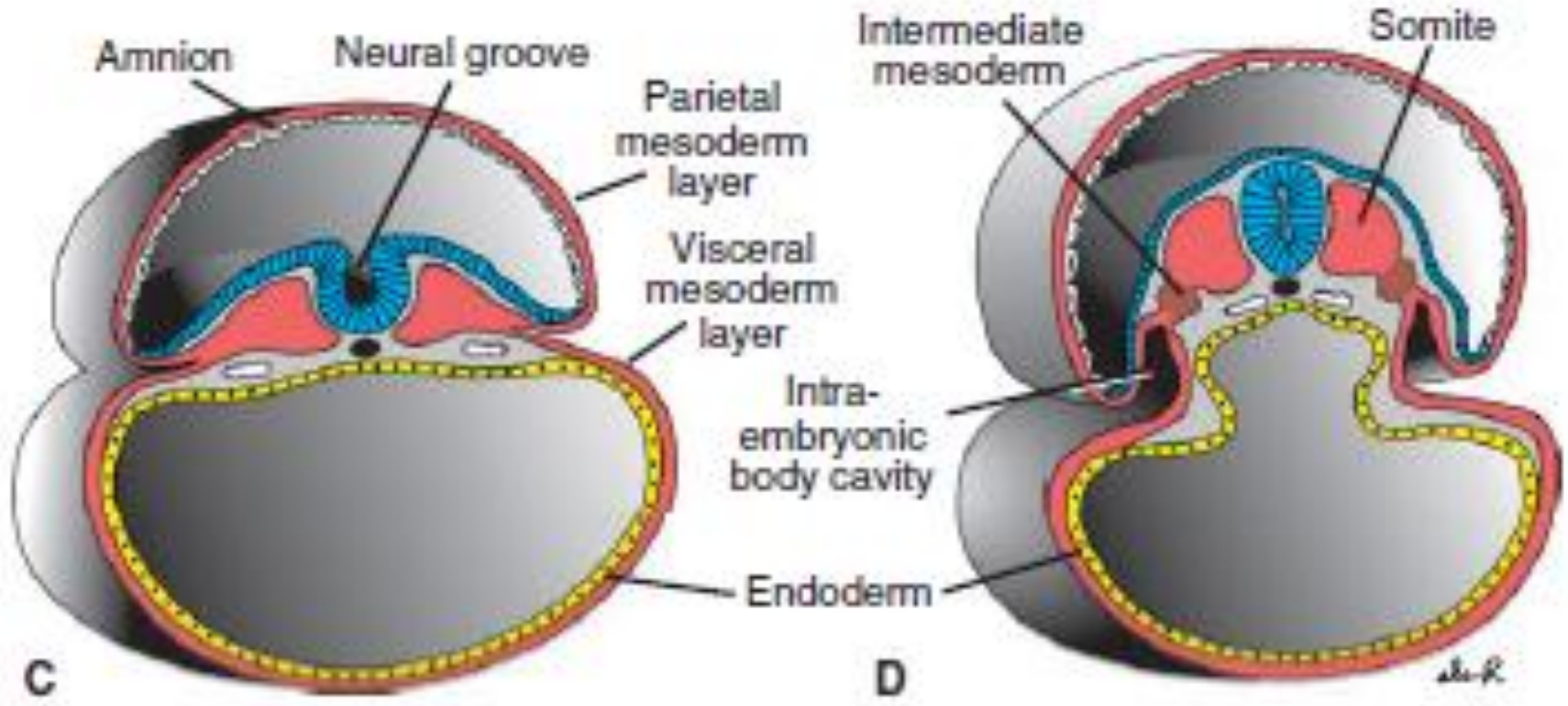
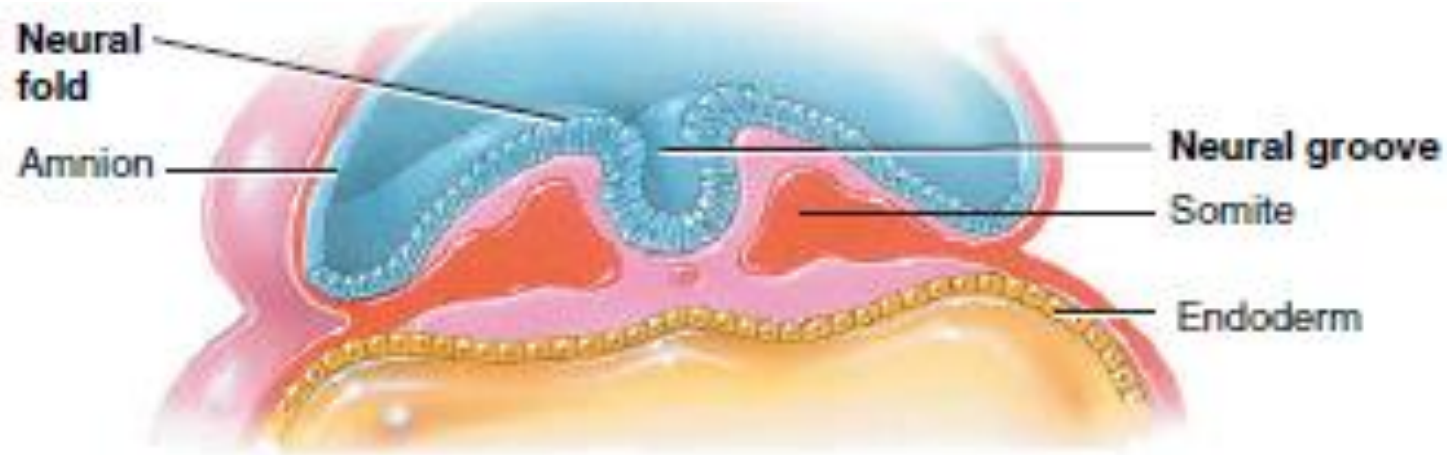


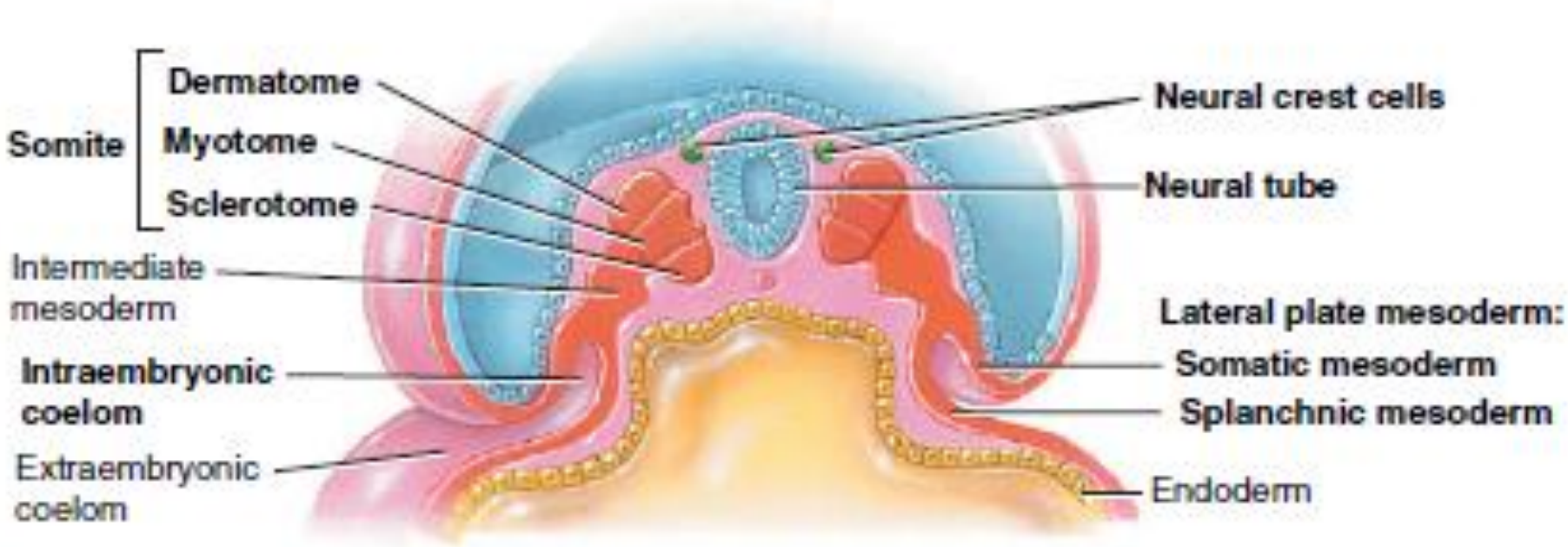
Fig. 5.7: Formation of intraembryonic coelom and its subdivisions


Amnion
Neural groove
Parietal mesoderm layer
Visceral mesoderm layer
Intra-embryonic body cavity
Endoderm
C
Intermediate mesoderm
Somite
D

- Cavity splits the lateral plate mesoderm into two parts the **splanchnic mesoderm** and **somatic mesoderm**
- **Splanchnic mesoderm or** Splanchnopleuric or visceral layer of intraembryonic mesoderm
- which is adjacent to the endoderm and yolk sac, forms:-
- the heart and the visceral layer of the serous pericardium, blood vessels, the smooth muscle and connective tissues of the respiratory and digestive organs, and the visceral layer of the serous membrane of the pleurae and peritoneum



(c) 20 days



(d) 22 days

Transverse sections

- **Somatic mesoderm or** Somatopleuric or parietal layer intraembryonic mesoderm
- Which is adjacent to the ectoderm and amnion, gives rise to:-
- the bones, ligaments, blood vessels, and connective tissue of the limbs and the parietal layer of the serous membrane of the pericardium, pleurae, and peritoneum
- intraembryonic coelom gives rise to **pericardial, pleural**, and **peritoneal cavities**

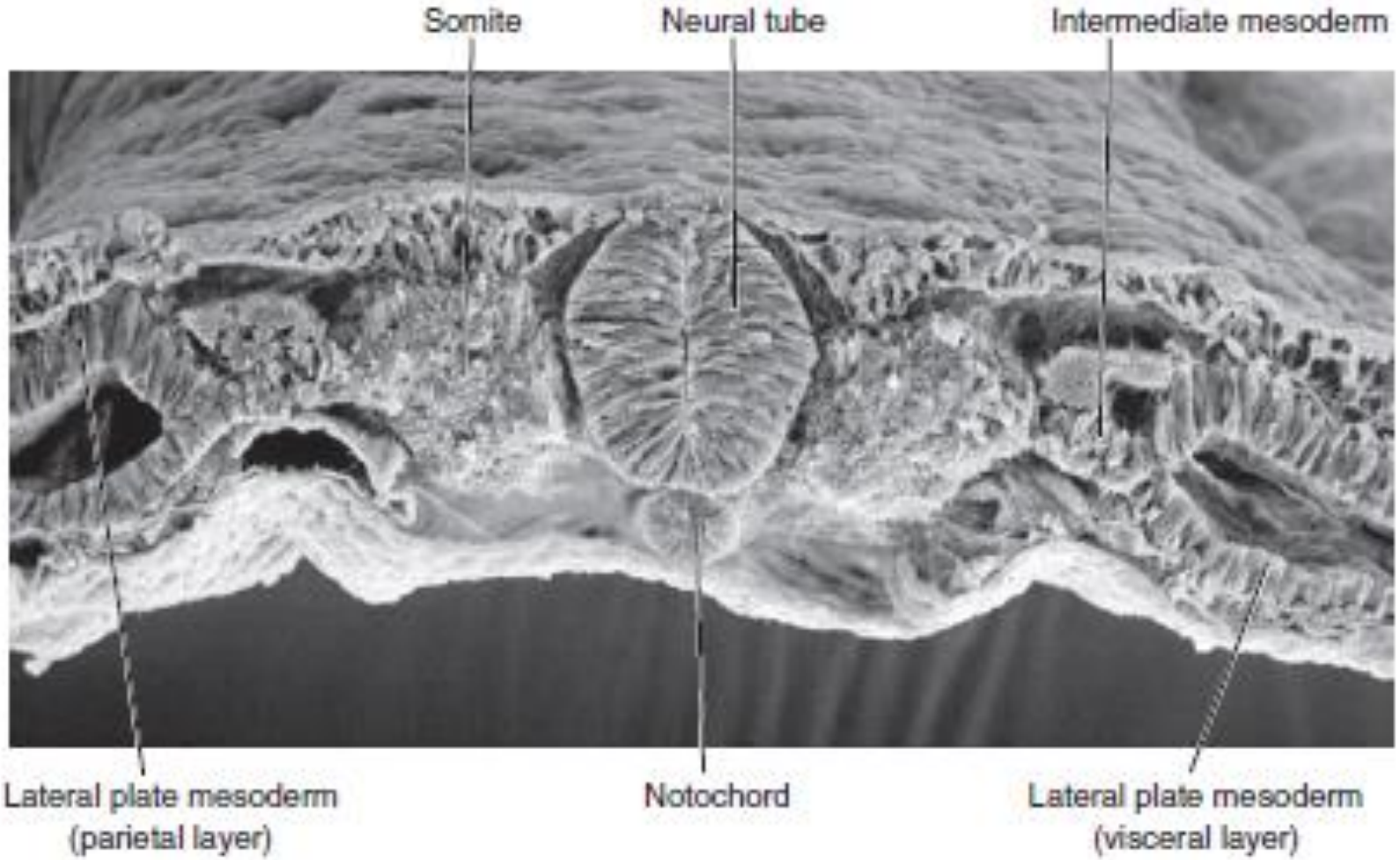


Figure 6.9 Cross section through the somites and neural tube showing the organization of the paraxial mesoderm into somites and intermediate and lateral plate mesoderm.

- the **pericardium** is formed from that part of the intraembryonic coelom that lies, in the midline, cranial to the prochordal plate
- Heart is formed in the splanchnopleuric mesoderm forming the floor of this part of the coelom called the *cardiogenic area* (also called *cardiogenic plate*, *heart-forming plate*)
- mesoderm which does not get split, as the intraembryonic coelom has not extended into it
- This unsplit part of intraembryonic mesoderm forms a structure called the ***septum transversum***

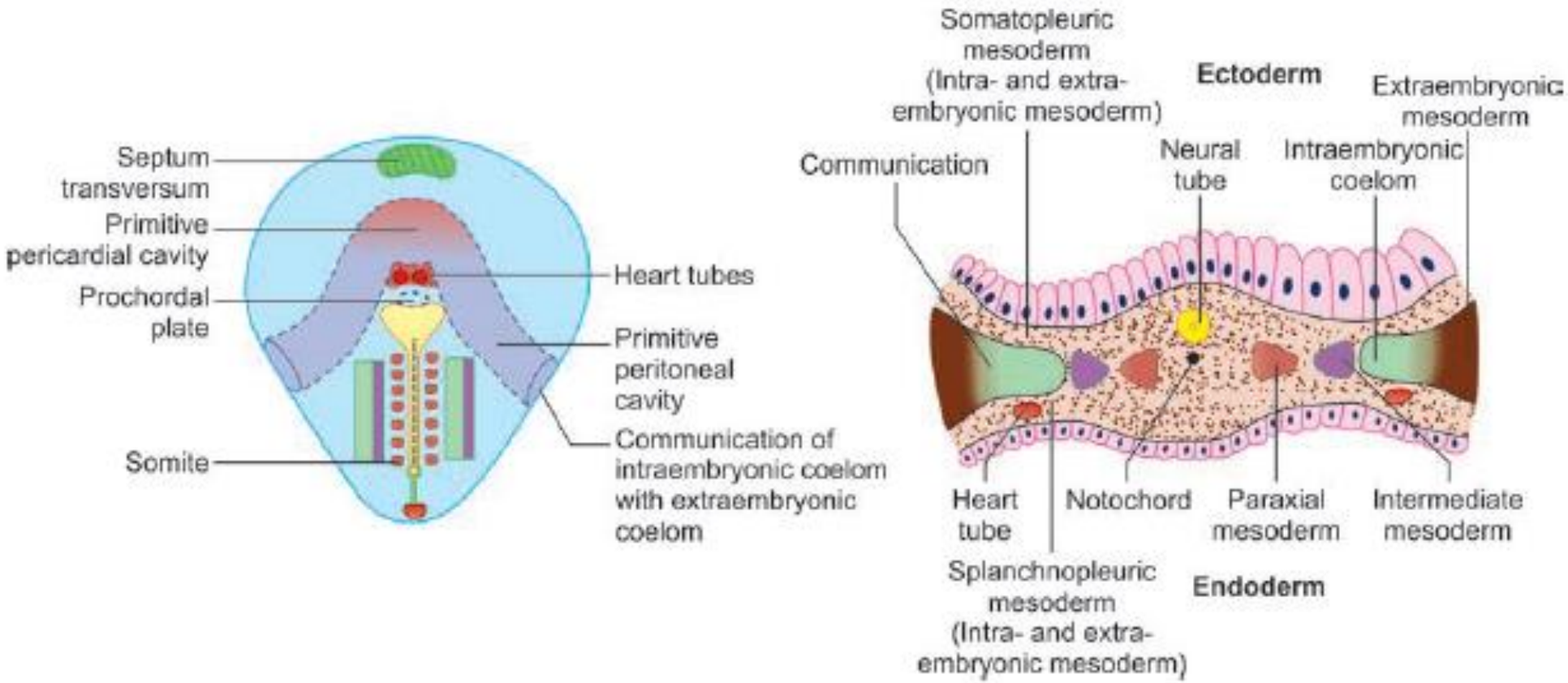


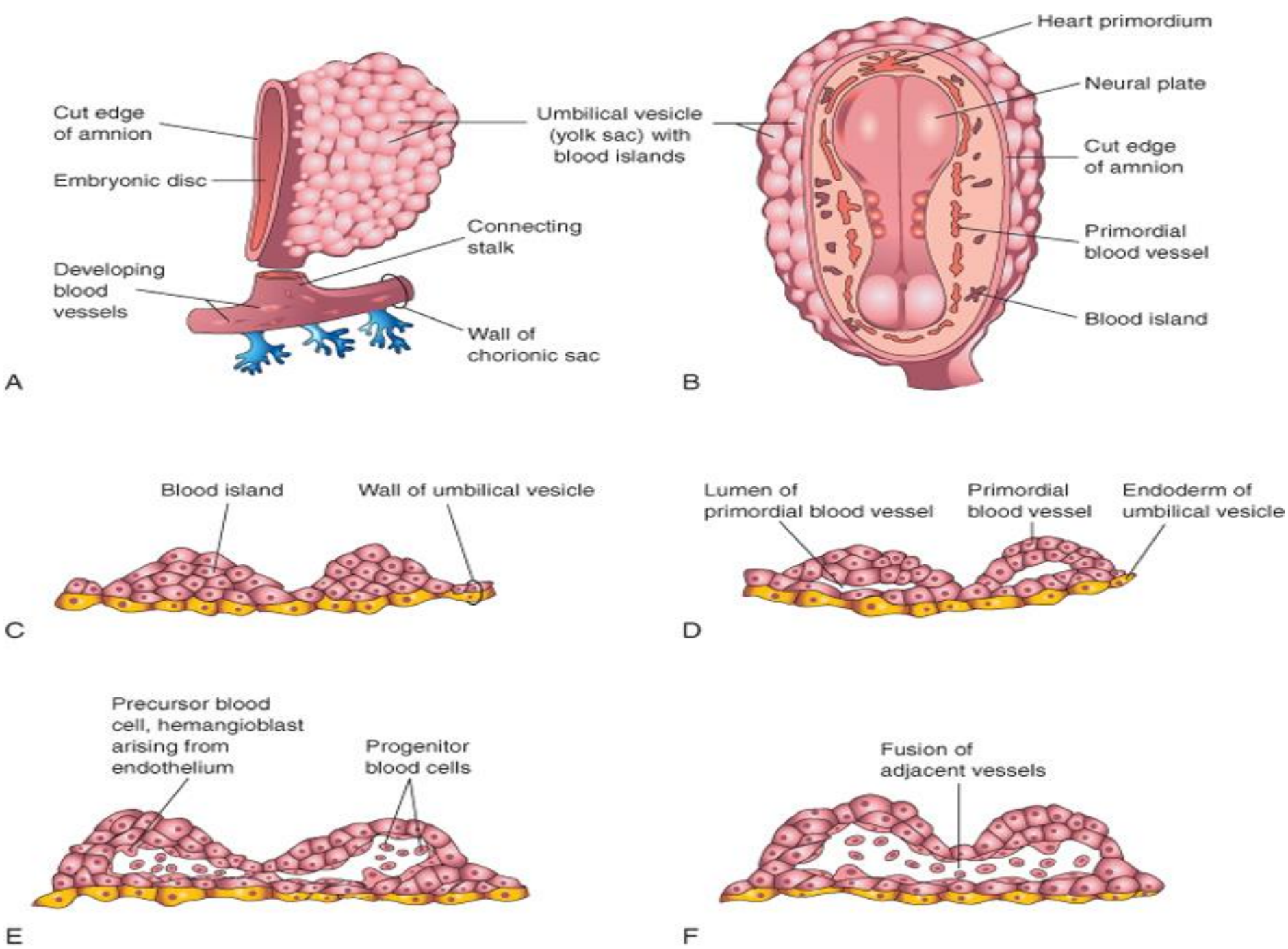
Fig. 5.8: Communication between intraembryonic coelom and extraembryonic coelom. Strucutres in the midline of germ disc before folding

- **INTERMEDIATE MESODERM**
- urinary and genital systems are derived from the intermediate mesoderm

- ***Development of the Cardiovascular System***
- At the beginning of the third week, *vasculogenesis* and *angiogenesis*, or blood vessel formation, begins in the extraembryonic mesoderm of the umbilical vesicle, connecting stalk, and chorion
- Embryonic blood vessels begin to develop approximately 2 days later
- early development is necessary because there is insufficient yolk in the yolk sac and ovum to provide adequate nutrition for the rapidly developing embryo

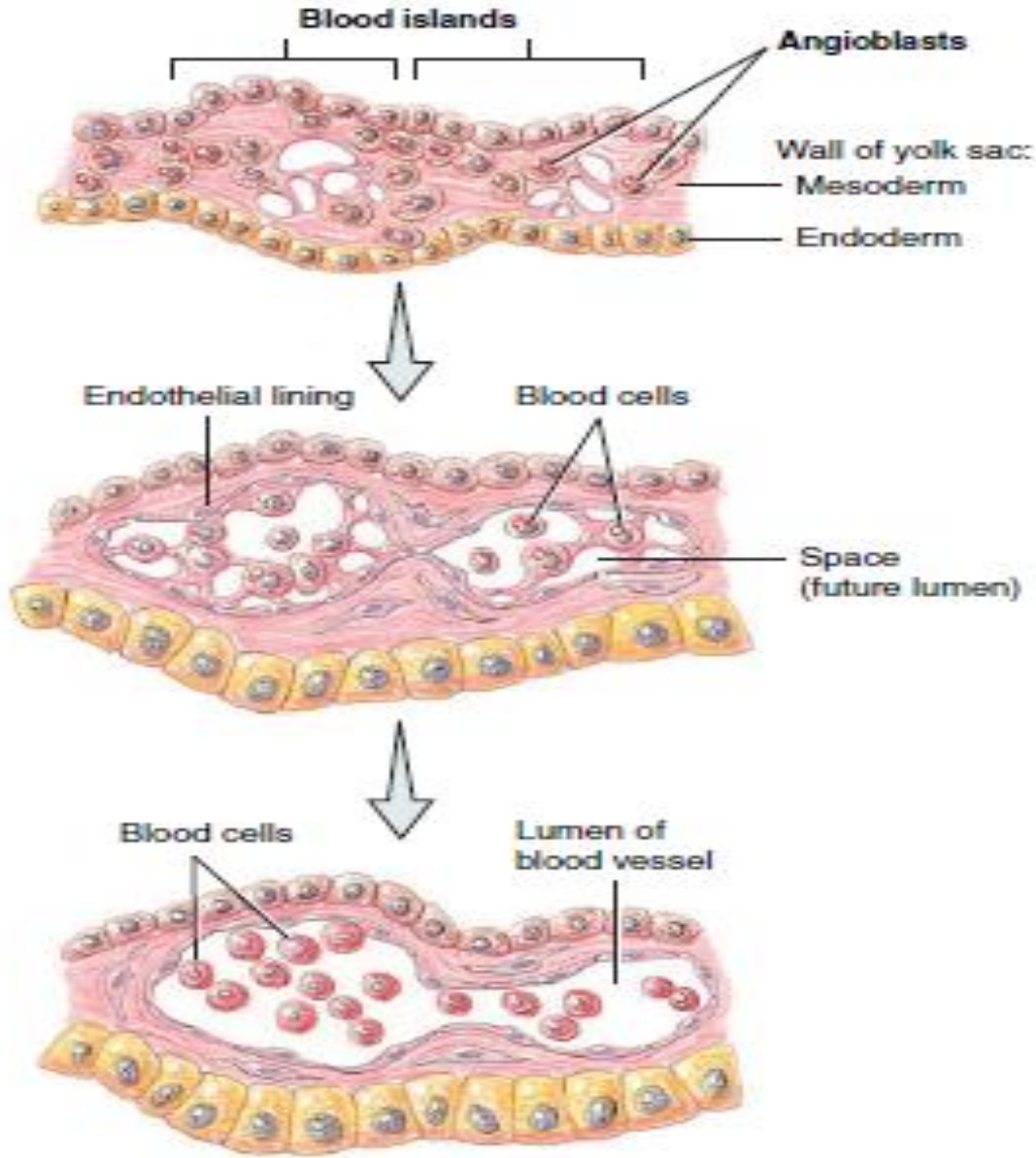
- The formation of the embryonic vascular system involves two processes: *vasculogenesis* and *angiogenesis*
- **Vasculogenesis** is the formation of new vascular channels by assembly of individual cell precursors called angioblasts
- **Angiogenesis** is the formation of new vessels by budding and branching from preexisting vessels

- Blood vessel formation (*vasculogenesis*) in the embryo and extraembryonic membranes may be summarized as follows:-
- initiated when mesodermal cells differentiate into **hemangioblasts**
- These then develop into cells called **angioblasts**, which aggregate to form isolated masses of cells referred to as **blood islands**
- As the blood islands throughout the embryonic mesoderm grow they fuse together, forming an extensive system of blood vessels within the embryo.

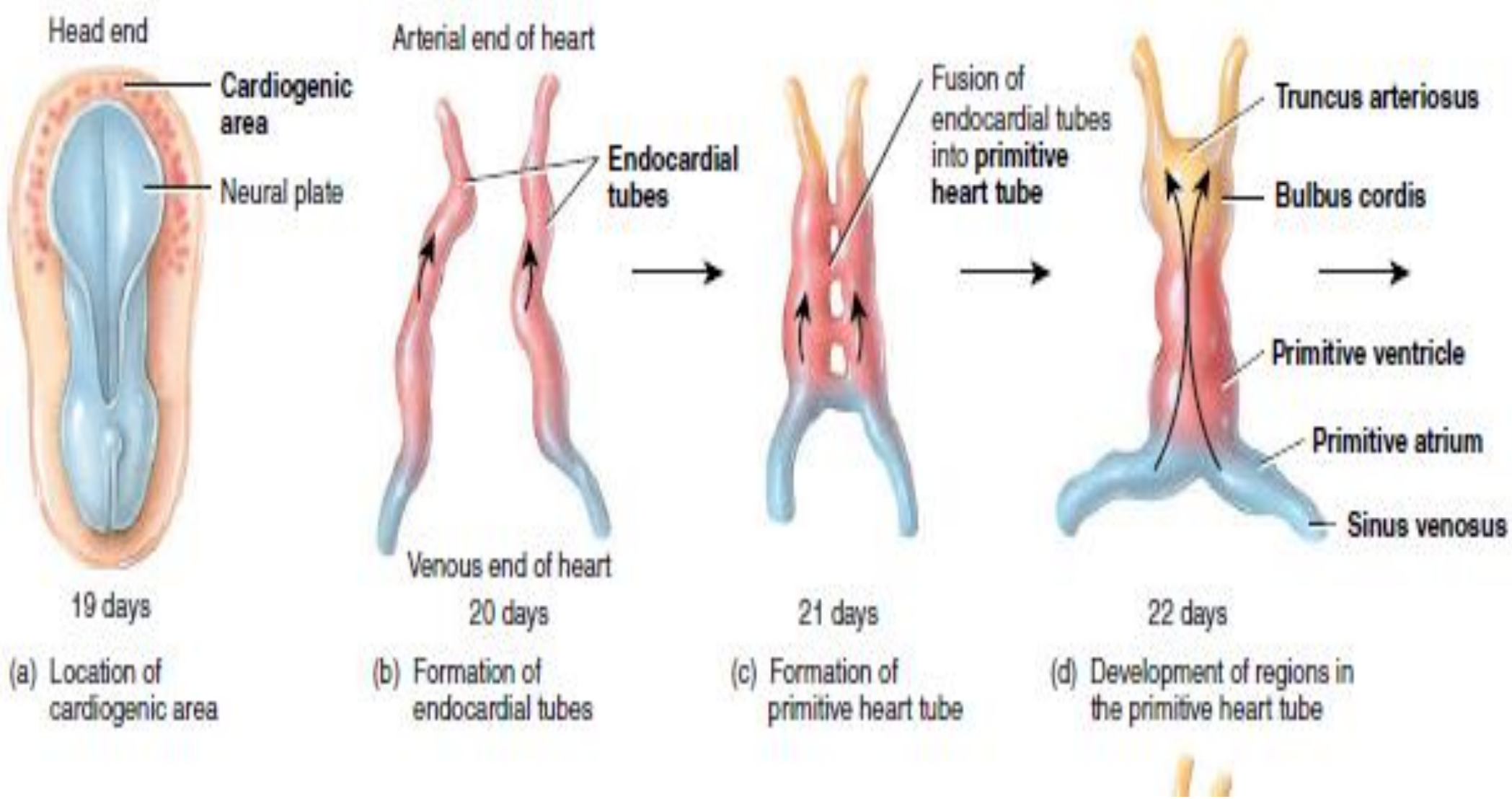


- End of 3rd week blood cells and blood plasma begin to develop *outside* the embryo—in the walls of the yolk sac, allantois, and chorion—from hemangioblasts in blood vessels
- These then develop into pluripotent stem cells that form blood cells
- Blood formation(hematogenesis) begins *within* the embryo at about the fifth week in the liver and around the twelfth week in the spleen, red bone marrow, and thymus
- Hemopoiesis first occurs before birth in the yolk sac of an embryo and later in the liver, spleen, thymus, and lymph nodes of a foetus
- In the last three months before birth, red bone marrow becomes the primary site of hemopoiesis
- continues to be the source of blood cells after birth and throughout life

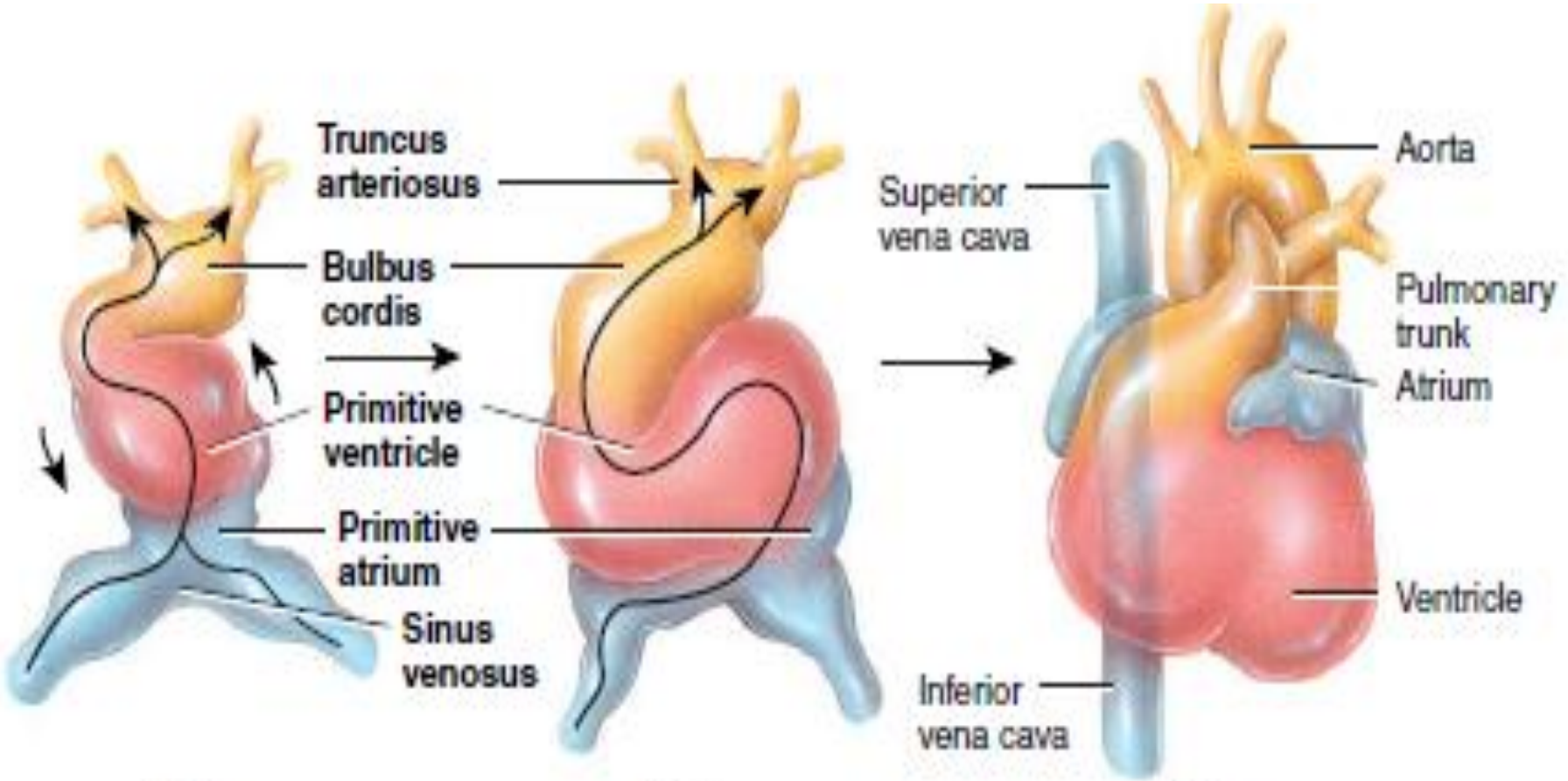
Blood vessel development begins in the embryo on about day 17 or 18.



- **The Primordial Cardiovascular System**
- **Heart and great vessels** forms from splanchnic mesoderm in the head end of the embryo on day 18 or 19 after fertilization
- This region of mesodermal cells is called the **cardiogenic area**
- In response to induction signals from the underlying endoderm, these mesodermal cells ultimately form a pair of **endocardial tubes**
- tubes then fuse to form a single **primitive heart tube**


Head end
Cardiogenic area
Neural plate
19 days
(a) Location of cardiogenic area
Arterial end of heart
Endocardial tubes
Venous end of heart
20 days
(b) Formation of endocardial tubes
Fusion of endocardial tubes into primitive heart tube
21 days
(c) Formation of primitive heart tube
Truncus arteriosus
Bulbus cordis
Primitive ventricle
Primitive atrium
Sinus venosus
22 days
(d) Development of regions in the primitive heart tube

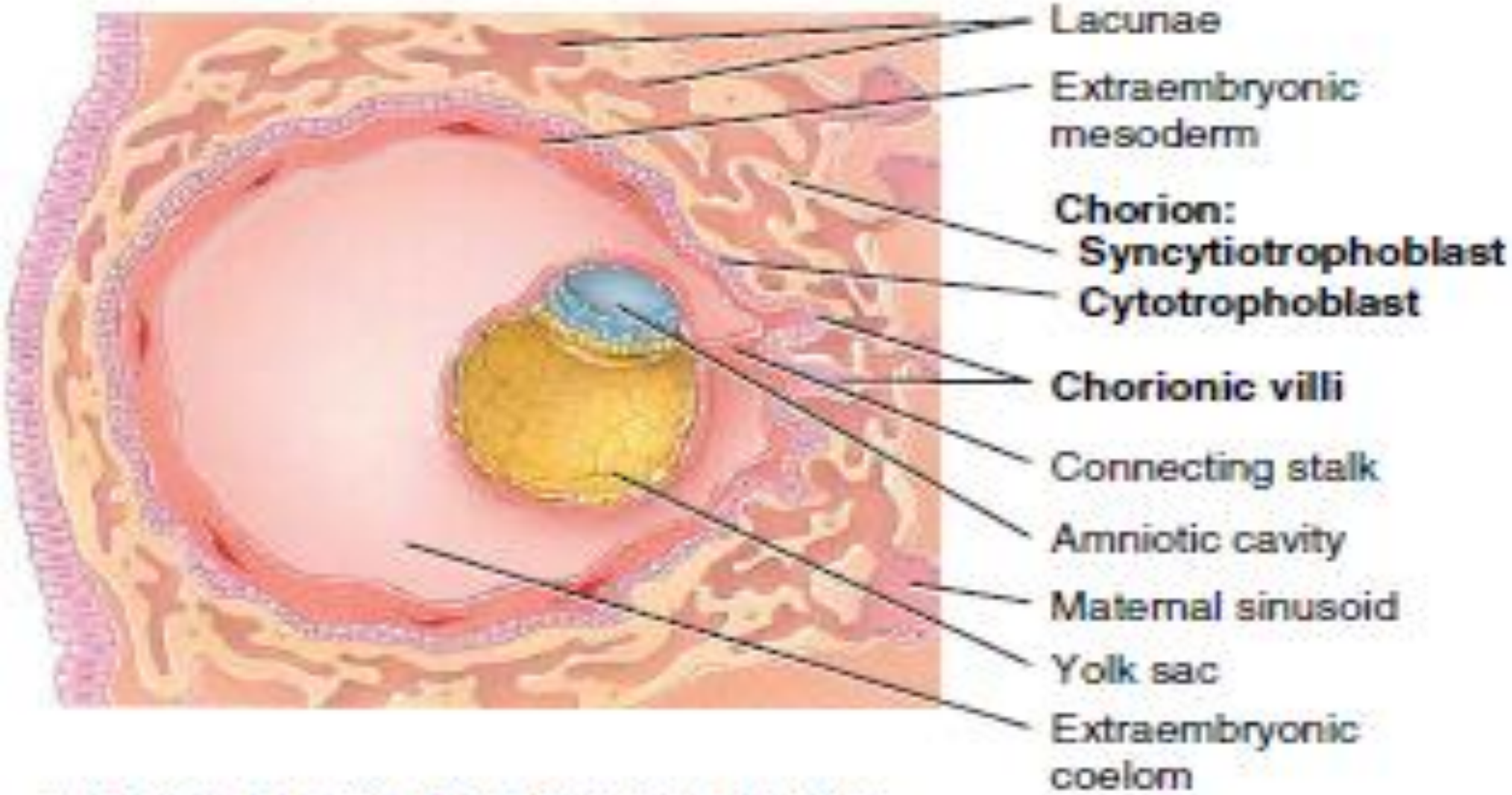
- the end of the third week, the primitive heart tube bends on itself, becomes S-shaped
- It then joins blood vessels in other parts of the embryo, connecting stalk, chorion, and yolk sac to form a primitive cardiovascular system
- By the end of the third week, the blood is circulating and the heart begins to beat on the 21st or 22nd day
- *cardiovascular system is the first organ system to reach a functional state*



(e) Bending of the primitive heart

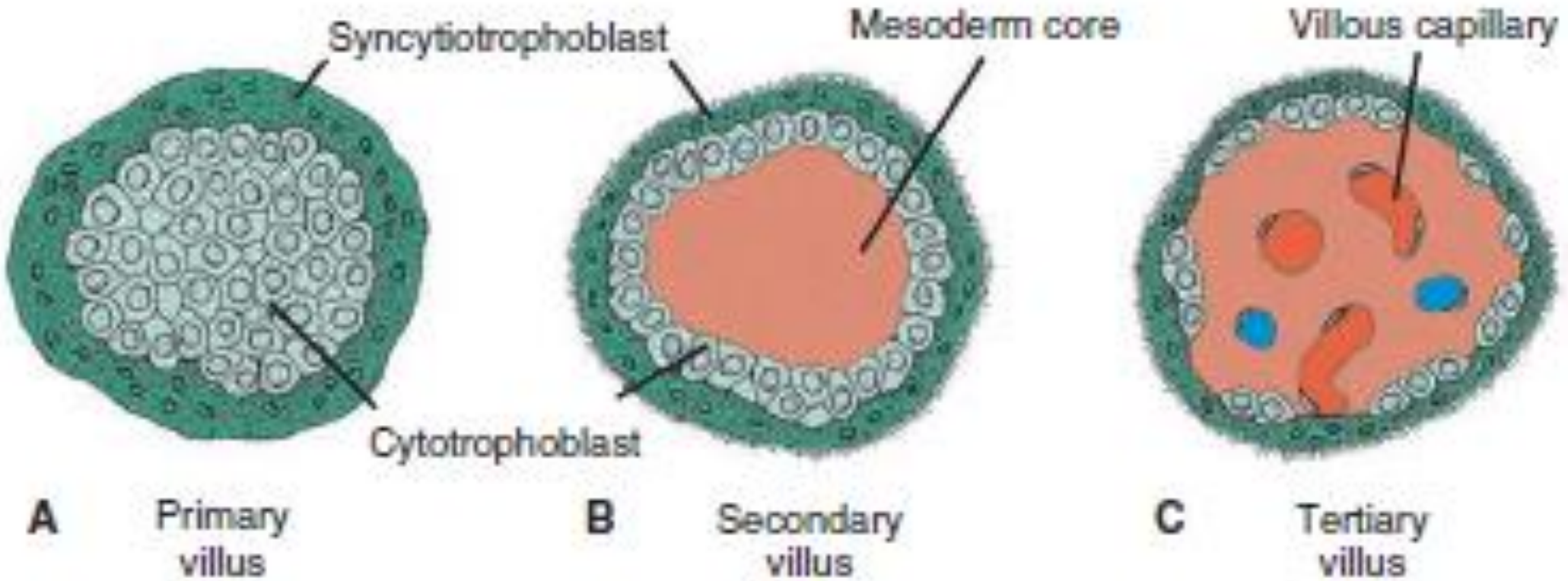
(f) Orientation of atria and ventricles to their final adult position

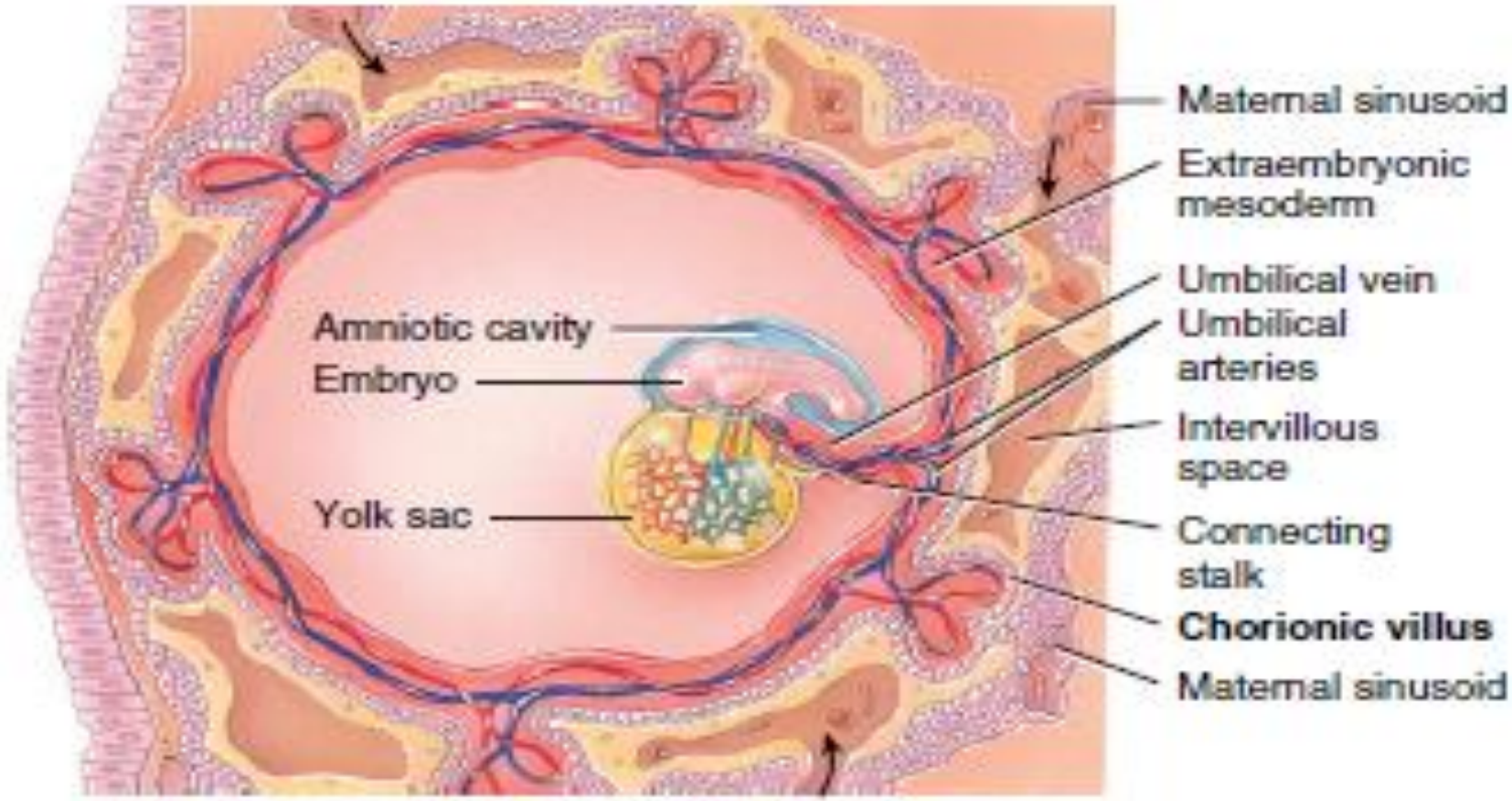
- **DEVELOPMENT OF CHORIONIC VILLI**
- As the embryonic tissue invades the uterine wall
- maternal uterine vessels are eroded and maternal blood fills spaces called **lacunae** within the invading tissue(syncytiotrophoblast)
- **primary chorionic villi** appear at the end of the second week, they begin to branch
- These fingerlike projections consist of chorion (syncytiotrophoblast surrounded by cytotrophoblast) that project into the endometrial wall of the uterus



(a) Frontal section through uterus showing blastocyst, about 13 days after fertilization

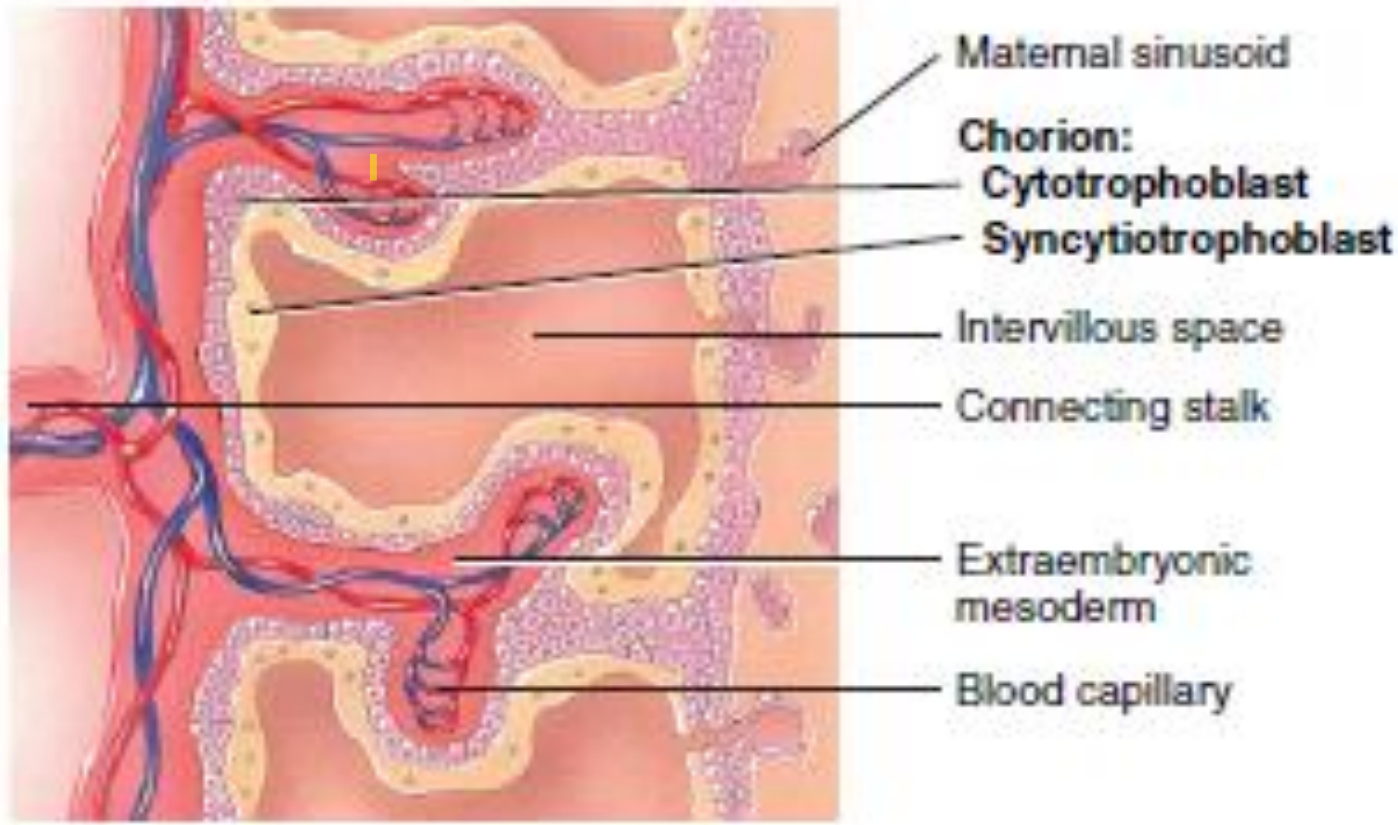
- Early in the third week, mesenchyme grows into these primary villi, forming a core of mesenchymal tissue
- villi at this stage-**secondary chorionic villi**-cover the entire surface of the chorionic sac
- Some mesenchymal cells in the villi soon differentiate into capillaries and blood cells
- They are called **tertiary chorionic villi** when blood vessels are visible in them
- Blood vessels in the chorionic villi connect to the embryonic heart by way of the umbilical arteries and umbilical vein through the connecting (body) stalk, which will eventually become the umbilical cord


Syncytiotrophoblast
Cytotrophoblast
Mesoderm core
Villous capillary
A
Primary villus
B
Secondary villus
C
Tertiary villus



(c) Frontal section through uterus showing an embryo and its vascular supply, about 21 days after fertilization

- The fetal blood capillaries within the chorionic villi project into the lacunae, which unite to form the **intervillous spaces** where the chorionic villi (and the fetal blood vessels within them) are bathed in maternal blood
- However maternal blood and fetal blood do not mix directly
- oxygen and nutrients in the mother's blood diffuse from the intervillous spaces across the plasma membranes of the chorion and the capillaries of the villi
- Waste products such as carbon dioxide diffuse in the opposite direction



(b) Details of two chorionic villi, about 21 days after fertilization