بسم الله الرحمٰن الرحيم

{مِن نُّطْفَةٍ خَلَقَهُ فَقَدَّرَهُ}

Embryology | FINAL

GIT
Embryology 1

Written by : Sara Al-khateeb

Reviewed by : Rama Ejueidi

Gi tract embryology 1

A tip for studying Embryology: when studying the development of any organ, **you should visualize its gross anatomy first. Understand the final structure, then link it back to its embryonic development.**

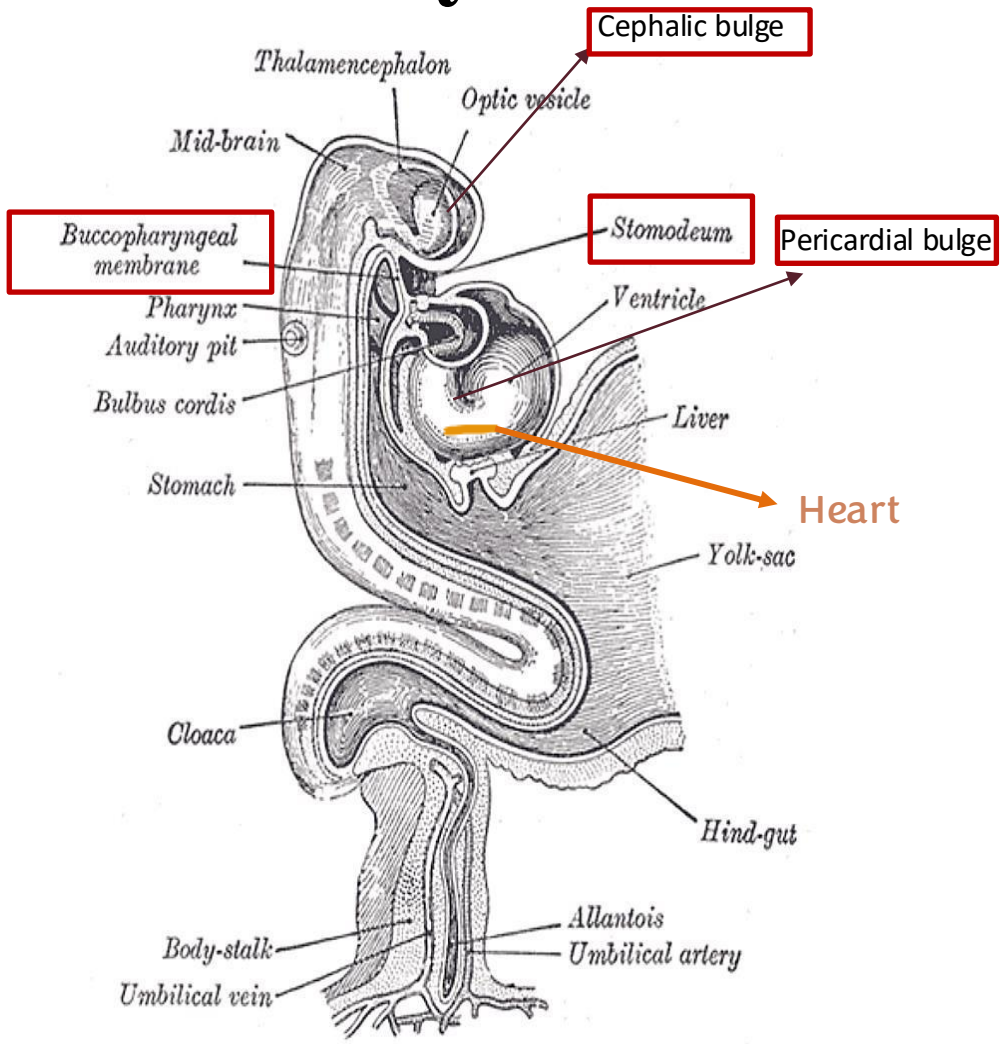
1- Development of the Oral Cavity

- The mouth has **two sources** of development:

✓ **Depression** in the **stomodeum** (lined with **ectoderm**) .

- The **stomodeum** is the ectodermal depression in the embryo that serves as the precursor of the **anterior part** of the **oral cavity.**

✓ **Cephalic end** of the foregut which is the pharynx/posterior part of the oral cavity (lined with **endoderm**)



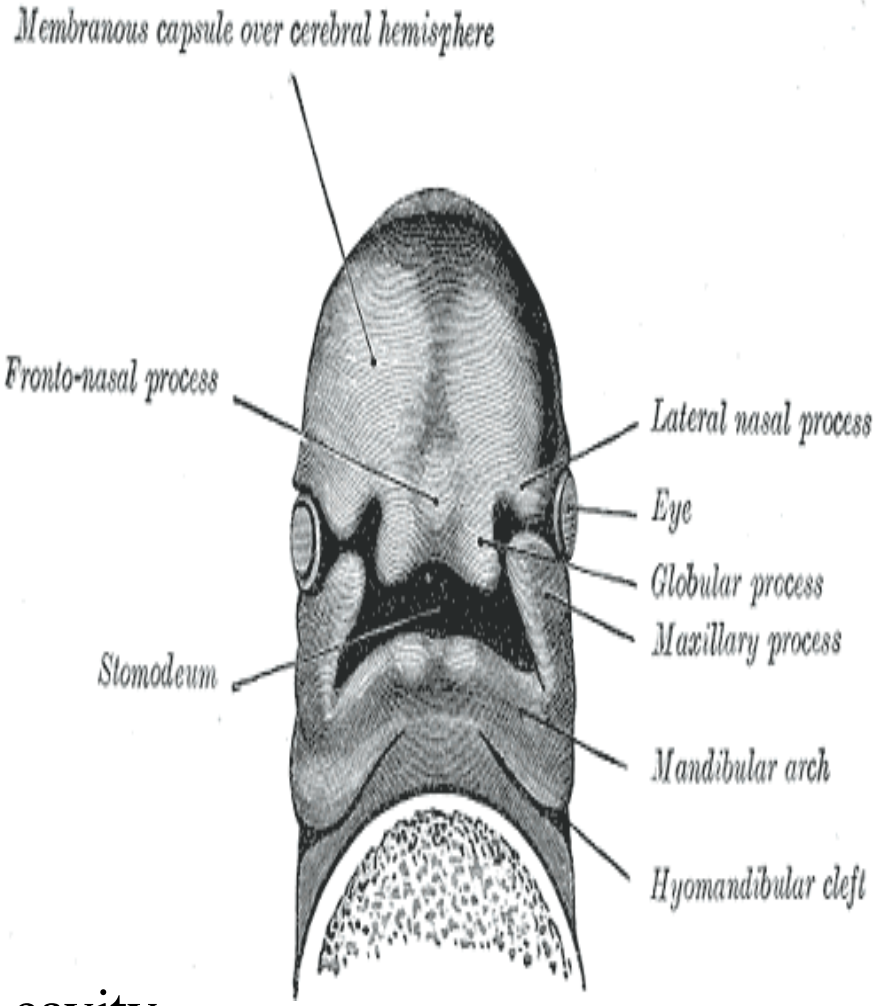
1- Development of the Oral Cavity

- These two points are separated by the **buccopharyngeal membrane** behind stomodeum. *Note the highlight in the previous slide picture*
- Bucco (buccal cavity) + pharyngeal (pharynx)

- Separates the ectodermal from the endodermal part in the oral cavity

- During the **3rd week** of development the **membrane disappears** (to become oral cavity)

- If the membrane persists (we create an imaginary line), it will extend to:



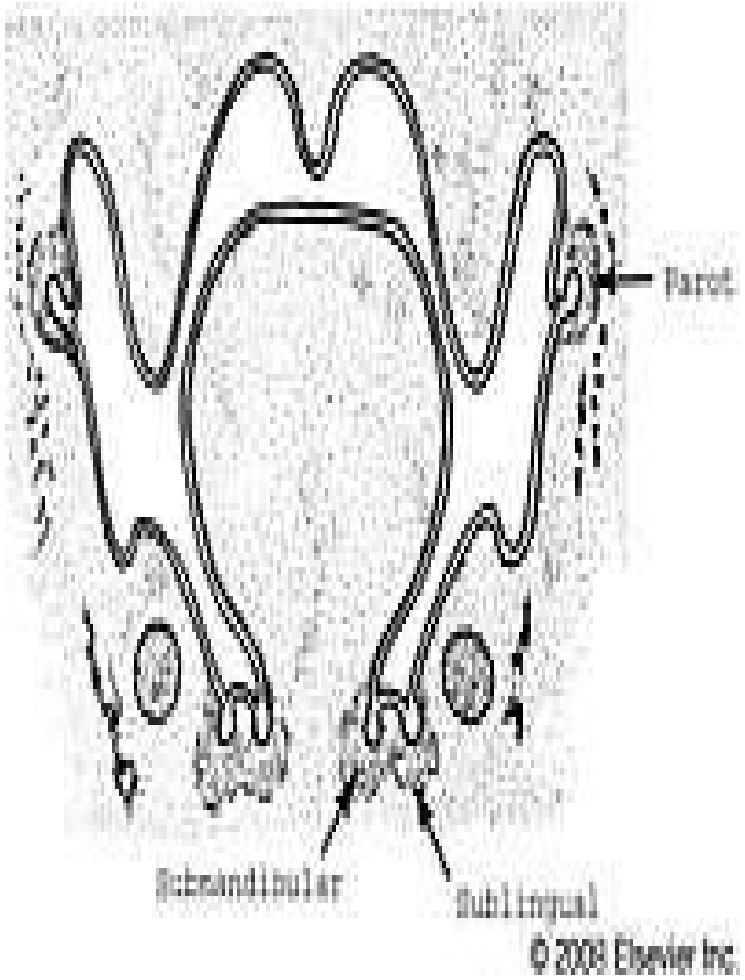
1. **Body of sphenoid** (The roof of the nasal cavity(
2. **Soft palate** (The end of the hard palate that separates the oral cavity from the nasal cavity)
3. **Inner surface of the mandible, inferior to the incisor teeth**

1- Development of the Oral Cavity

Location Relative to the Plane	Origin	Structures
Anterior to the plane	**Ectoderm (Epithelium)**	• Hard palate • Sides of the mouth • Lips • Enamel of the teeth
Posterior to the plane	**Endoderm**	• Tongue (attached to the floor of the mouth). • Soft palate • Palatoglossus and palatopharyngeal fold (The two folds of the oropharyngeal isthmus). Floor of the mouth.

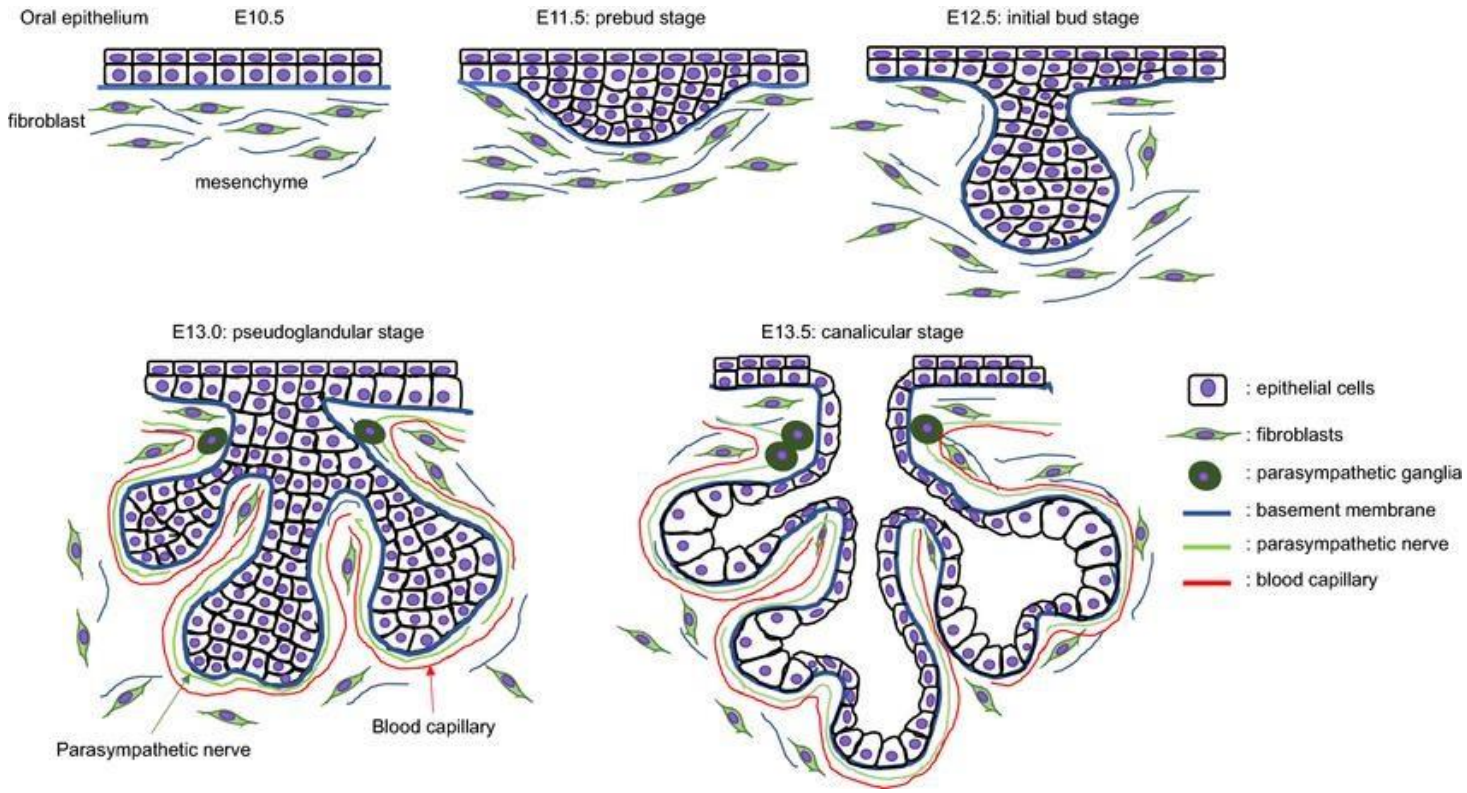
2- Development of the Salivary Glands

- ✓ During the **7th week** it arises as a **solid outgrowth** of cells from the walls of the developing mouth.
- ✓ Epithelial cells receive signals-during the **7th week**- from surrounding **mesenchymal tissue proteins** that stimulate their growth.
- ✓ In response, the epithelial cells **invaginate** into the **underlying mesenchyme**.
- ✓ **Rule**: growth always takes place in the mesenchyme
- ✓ The epithelial buds will go through repeated branching to form **solid ducts**
- ✓ The ends of these ducts will form the **secretory acini**, and they will both go through **canalization**



2- Development of the Salivary Glands

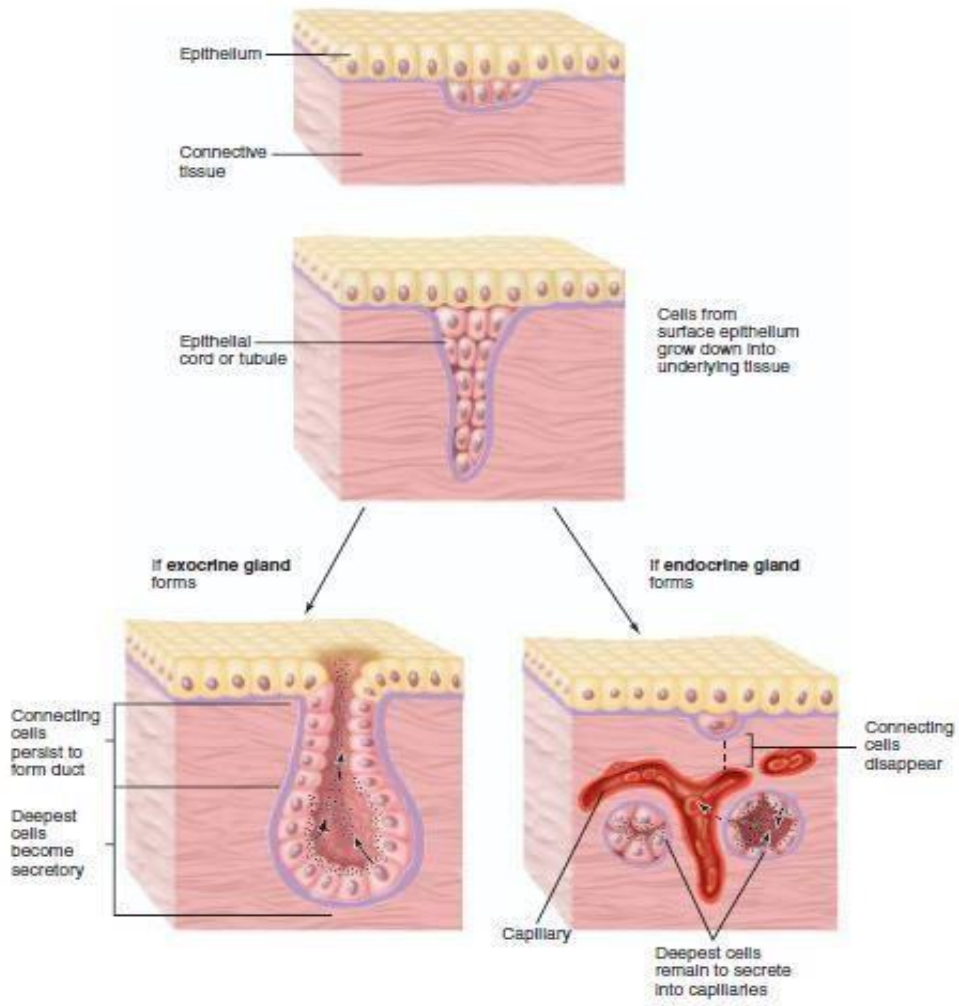
- Both endocrine and exocrine glands develop through the proliferation of surface epithelium that invades the underlying connective tissue.



Additional graph

3- Development of the Glands

- ✓ The development always starts from the surface, the surface in the oral cavity is the epithelium (stratified squamous epithelium non keratinized).
- ✓ Some glands retain their continuity with the surface via a duct and are known as **EXOCRINE** glands**, as they maintain contact with the surface** like **salivary glands.**
- ✓ Other glands lose this direct continuity with the surface when their ducts degenerate during development. These glands are known as **ENDOCRINE** glands, and they lose contact with the surface. Like **thyroid, pituitary, and adrenal glands.** (release hormones directly into the BV that are derived from mesenchymal cells)
- ✓ Endocrine glands are either arranged in **cords** or **follicles**



- ✓ Exocrine: Acini with lumen in the centre, canalization of the cells forms the duct that opens into the surface

	Presence of Ducts	Secretion Type	Vascularization
Exocrine	Present	Enzymes mostly secreted to digestive system	Moderate blood supply.
Endocrine	ductless	Hormones secreted directly into the bloodstream.	Highly vascularized

3- Development of the Glands

- ✓ The surrounding mesenchyme will **condense** to form:

1. **The capsule of the gland** (derived from mesoderm, dividing the gland into lobes)
2. **Septa that divide the gland into different lobes and lobules**

- ✓ The ducts and acini of the **parotid gland** are both derived from the **ectoderm**

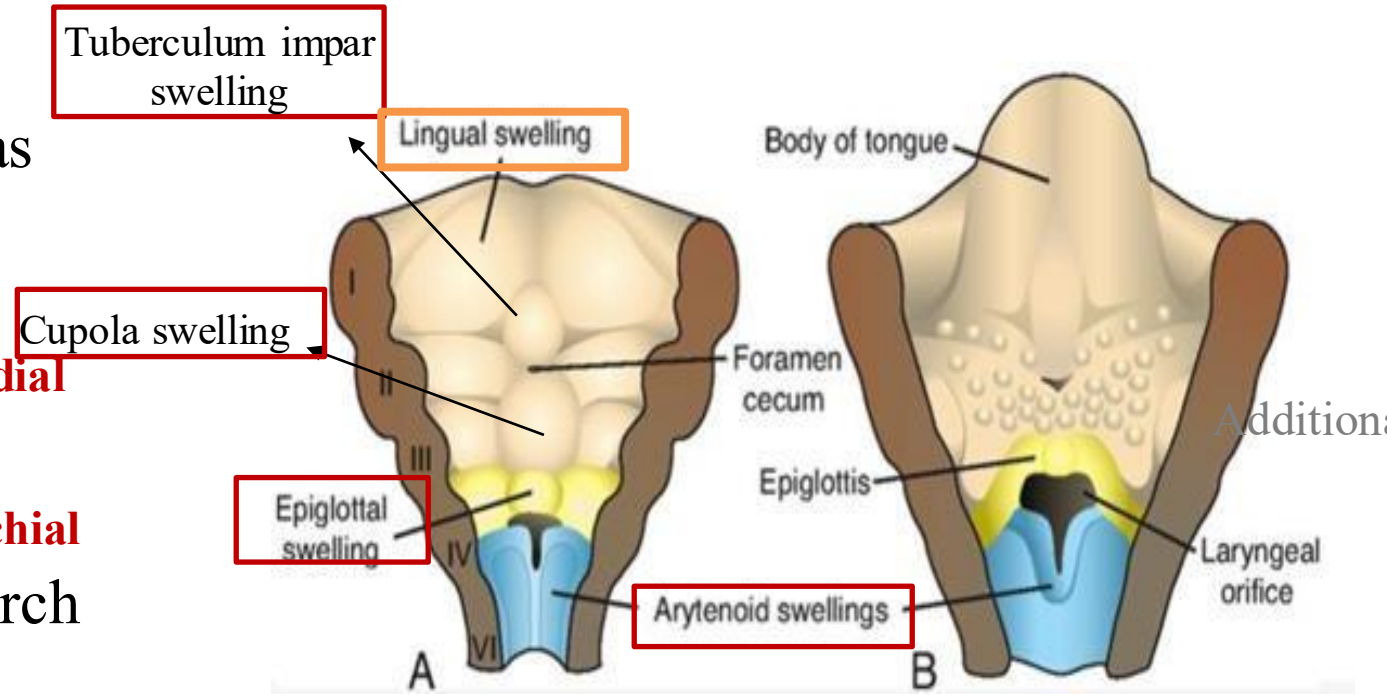
- ✓ **Submandibular and sublingual** glands are derived from the **endoderm**

4- Tongue Development

- ✓ Each arch contains endodermal inside , mesodermal in the middle and ectodermal outside
- ✓ There are 5-6 pharyngeal arches. The 1st four take part in the formation of the tongue.
- ✓ There are **4 swellings** in these arches as <u>precursors of the tounge</u>
- ✓ distributed as:

1. 3 from the first arch**[2 lateral swelling, medial tuberculum impar]**
2. and the fourth swelling**[cupola/ hypobranchial eminence]** is from 2nd 3rd upper part of 4th arch

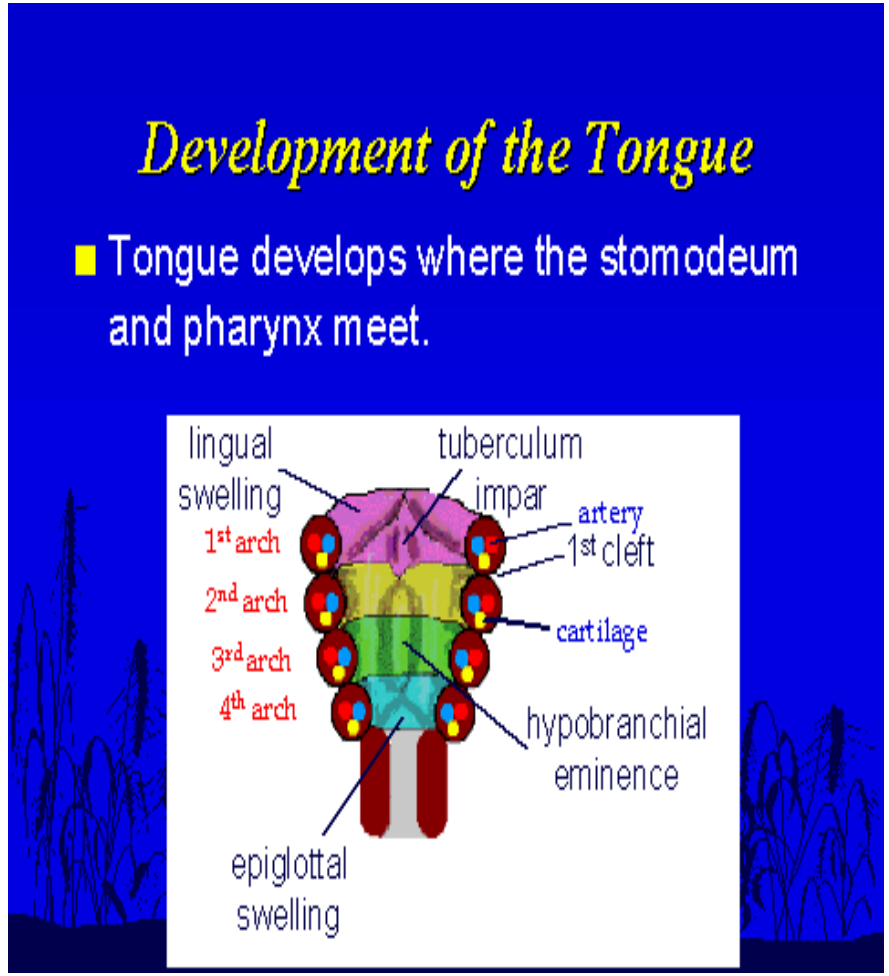
- ✓ Also there is <u>swelling for epiglottis</u> & <u>arytenoids swellings</u> (third medial swelling form the posterior part of the fourth pharyngeal arch forming the epiglottis)



- ✓ Muscles, bones and blood are derived from mesoderm, endoderm invade the mesoderm to form the glands

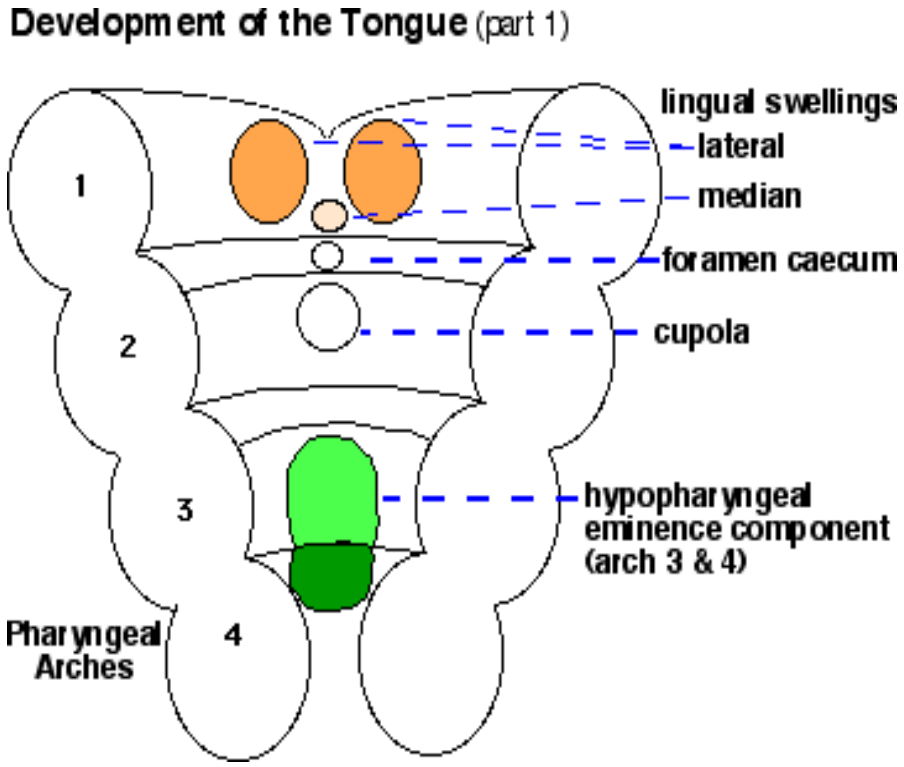
5- Anterior 2/3 of the Tounge Development

- ✓ As the lateral lingual swellings and the median swelling (tuberculum impar) develop, they undergo fusion at the midline. This results in the tongue being divided into symmetrical right and left halves, possessing identical neurovascular supply.
- ✓ The tongue appears in embryos of approximately **4 weeks**
- ✓ The three swellings originate from the **first pharyngeal** arch form the **anterior two-thirds, or body, of the tounge** as the lateral lingual swellings increase in size, they overgrow the tuberculum impar and merge.
- ✓ Since the mucosa covering the body of the tongue originates from the first pharyngeal arch, **sensory innervation to this area is by** the **mandibular branch of the trigeminal nerve.** (anterior 2/3 of the tongue general sensation innervated by lingual of mandibular)



6- Posterior 1/3 of the Tounge Development

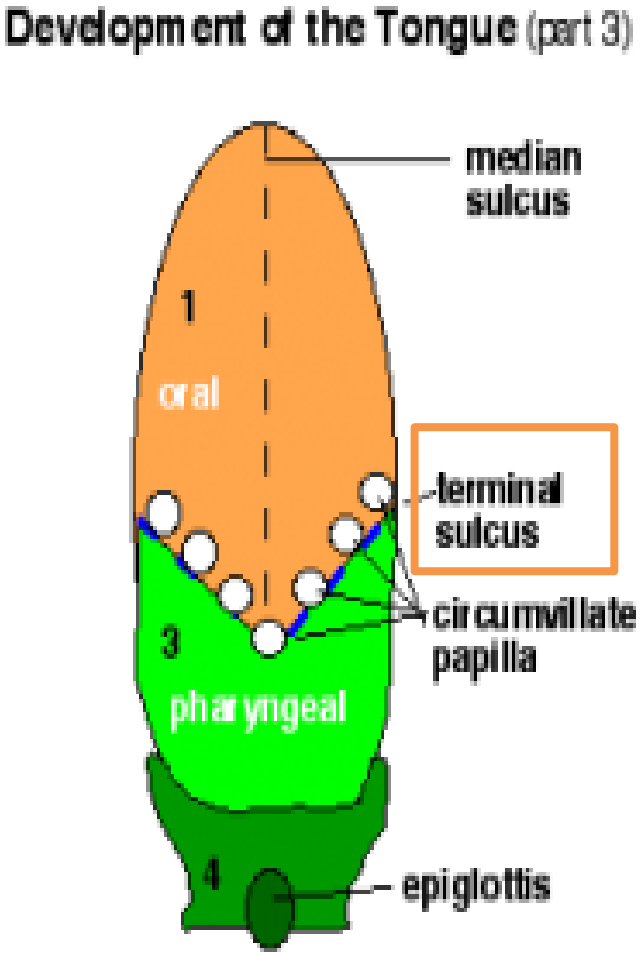
- ✓ the **copula** is the origin of the posterior part ,or the root, of the tounge.
- ✓ The **sensory** (and taste) **innervation to** this part of the tongue is supplied by the **glossopharyngeal nerve indicates that** tissue of the third arch overgrows that of the second.
- ✓ The body of the tongue is separated from the posterior third by a V-shaped groove, the **terminal sulcus**



7- Circumvallate Papillae Origin

- ✓ During embryonic development, **circumvallate papillae** originate from the posterior one-third of the tongue, which is derived from the endoderm and innervated by the **glossopharyngeal nerve (CN IX).**

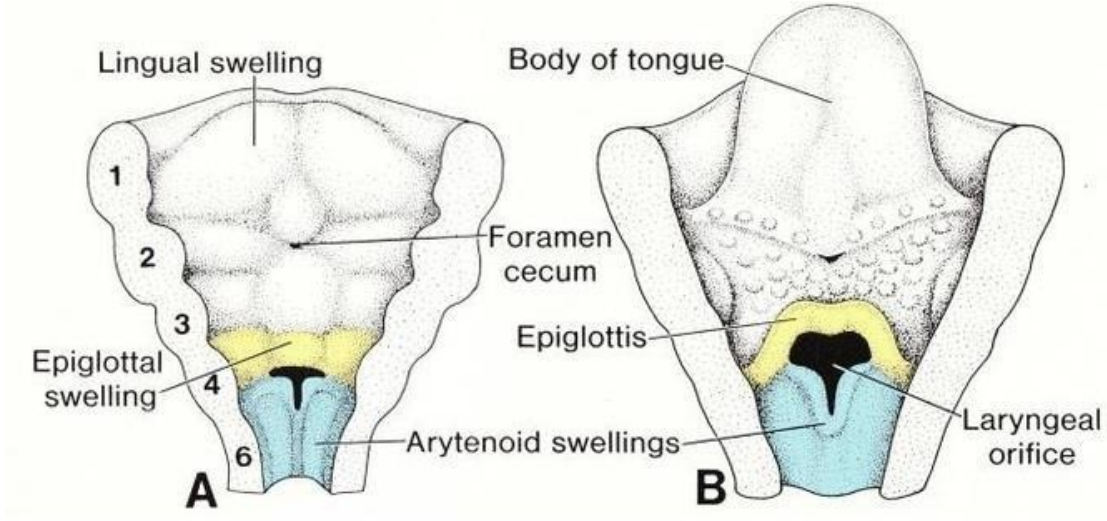
- ✓ Although they **later migrate anteriorly** and are found in front of sulcus terminalis in the adult tongue, **they retain their original innervation from the glossopharyngeal nerve**, reflecting their developmental origin.



8- Epiglottis & Arytenoid Development

- ✓ The swelling formed by the posterior part of the **fourth arch**, marks development of the epiglottis.

- ✓ The epiglottis and the extreme posterior part of the tongue are innervated by the **superior laryngeal nerve** (branch of the vagus) **, reflecting their development from the fourth** arch.
- ✓ Immediately behind this swelling is the **laryngeal orifice, which is flanked by the arytenoids swellings**



Additional graph

9- Tounge Muscles Development

- ✓ Some of the tongue muscles probably differentiate in situ, but most are **derived from myoblasts** originating in **occipital somites** (except for the palatoglossus not innervated by the Hypoglossal nerve, instead is innervated by the Vagus nerve (CN X)).

- ✓ Thus, tongue musculature is innervated by the **hypoglossal nerve.**

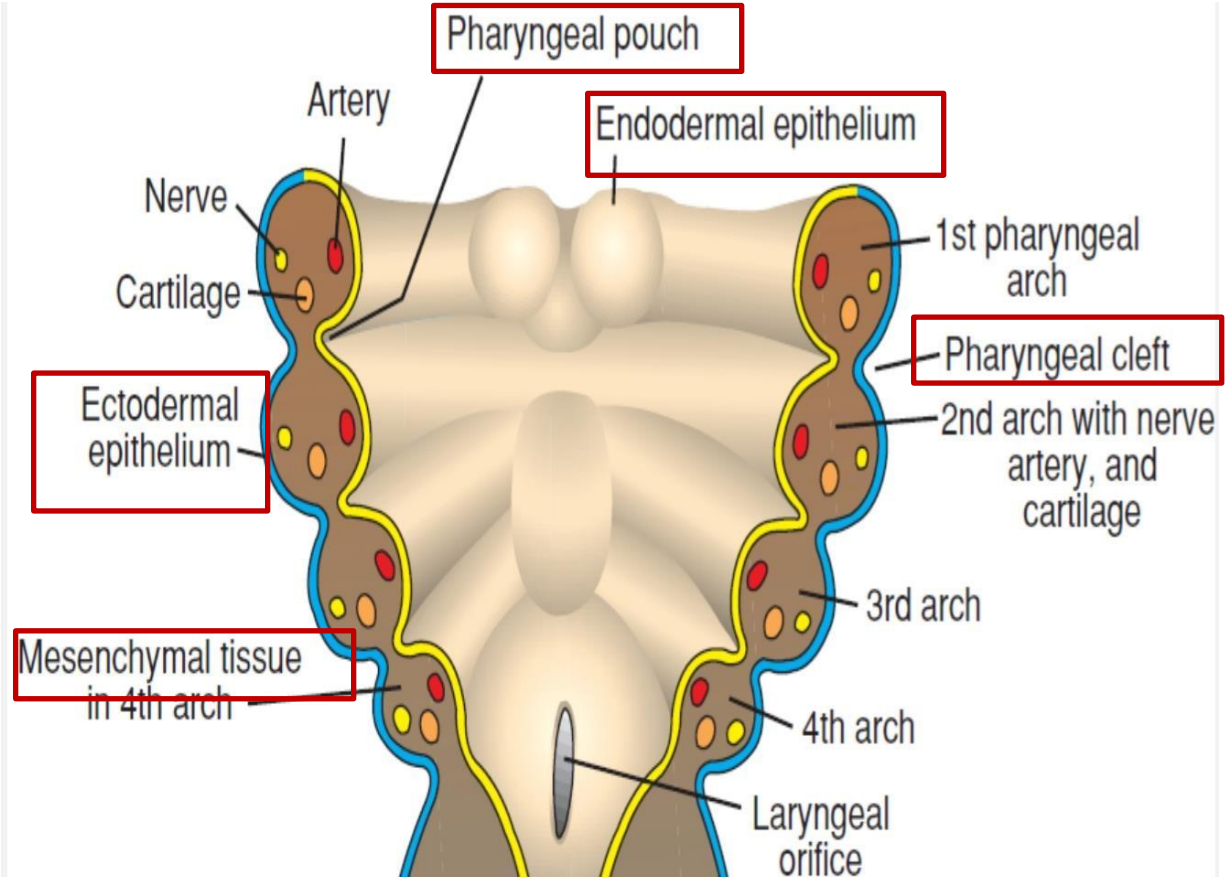
- ✓ **Special sensory innervation (taste)** to the anterior two thirds of the tongue is provided by the **chorda tympani** ,branch of the facial nerve.

- ✓ While the posterior third is supplied by the **glossopharyngeal nerve.**

10- Development of the Pharynx

- The pharynx-in embryo- is the region of the upper part of the foregut where the pharyngeal arches develop, and these arches contribute to the formation of structures in the head and neck.
- **The arches are composed of:**

1. External ectodermal layer
2. Internal endodermal layer
3. Mesenchymal layer between the above two layers



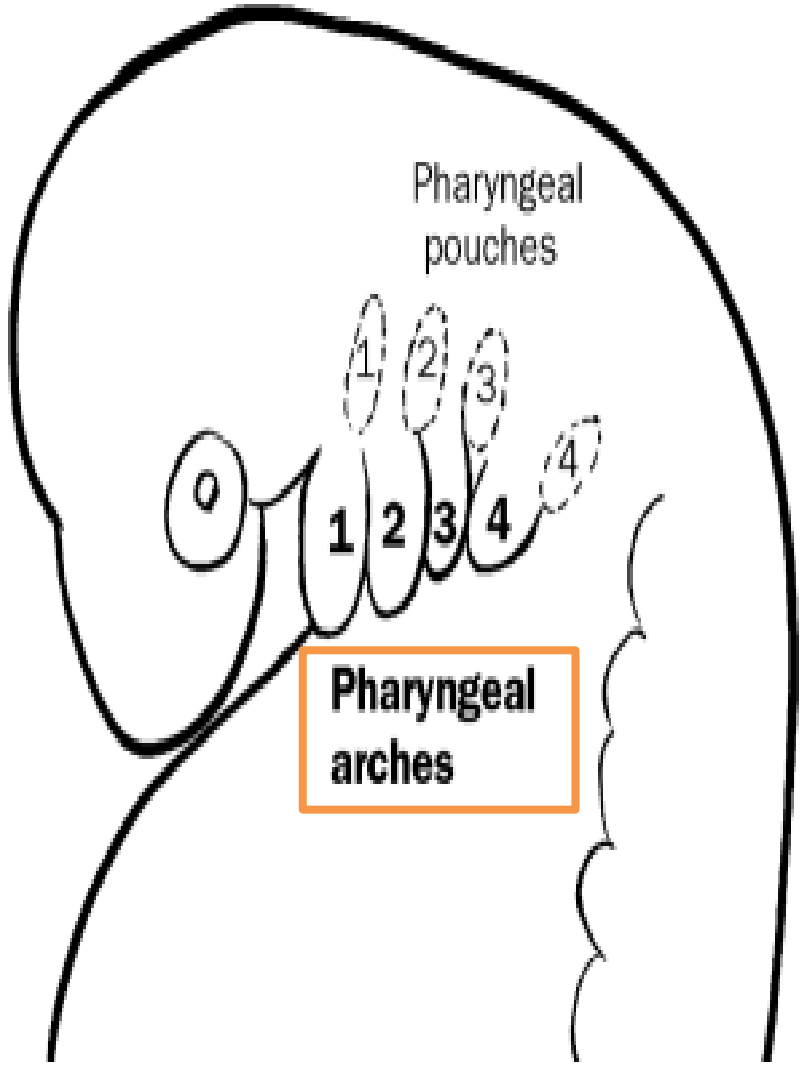
Additional graph

10- Development of the Pharynx

- ✓ Mesenchymal layer is **swollen** in each arch forming **clefts** (in ectodermal layer) and **pouches** (in endodermal layer), these two structures **separate the arches**

- ✓ The **lining epithelium** of the pharynx originats from the **endodermal** component of the pharyngeal arches including the pharyngeal pouches.

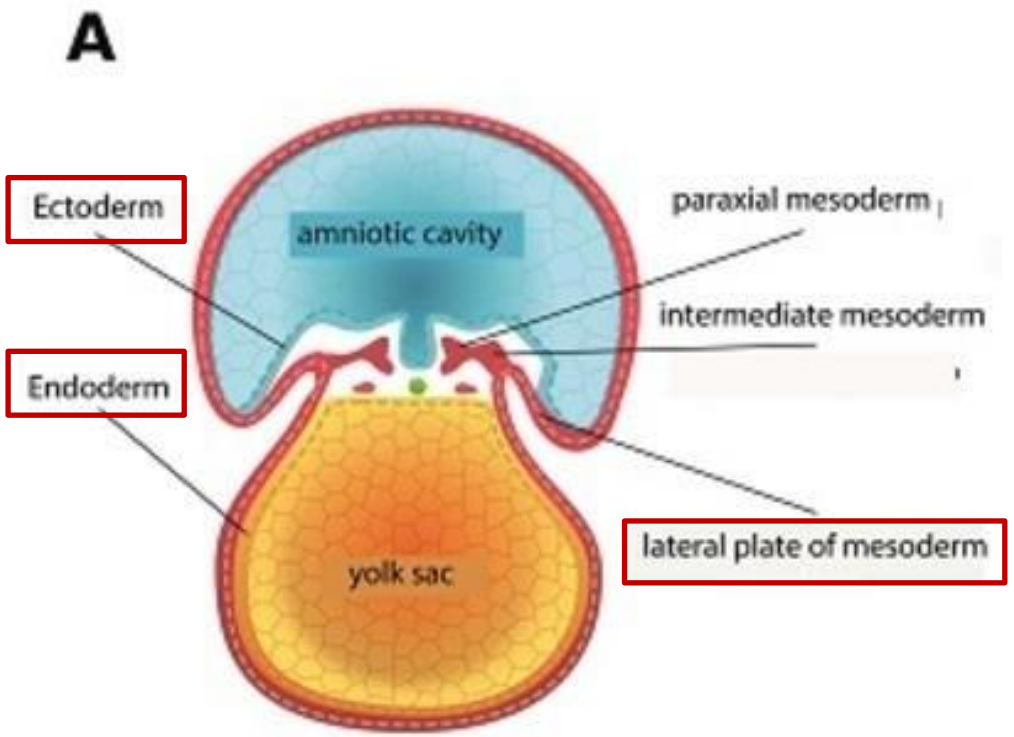
- ✓ The **muscles** and **connective tissue** of the pharynx originate from the **mesoderm**.



11- Development of the Anterior Abdominal Wall

This slide is not for memorization, just for clear understanding

- ✓ Remember that the anterior abdominal wall consists of the rectus abdominis muscle within the rectus sheath, as well as the external oblique, internal oblique, and transversus abdominis muscles.
- ✓ **Recall from introductory embryo, the stages of embryonic development:**
- ✓ [A]In the graph we can see the three layers of embryonic development, ectoderm, mesoderm and endoderm.
- ✓ **Note that:** the lateral plate of mesodermal layer is separated <u>giving two extra-embryonic layers to line the amniotic cavity and the yolk sac</u>.



Additional graph

11- Development of the Anterior Abdominal Wall

This slide is not for memorization, just for clear understanding

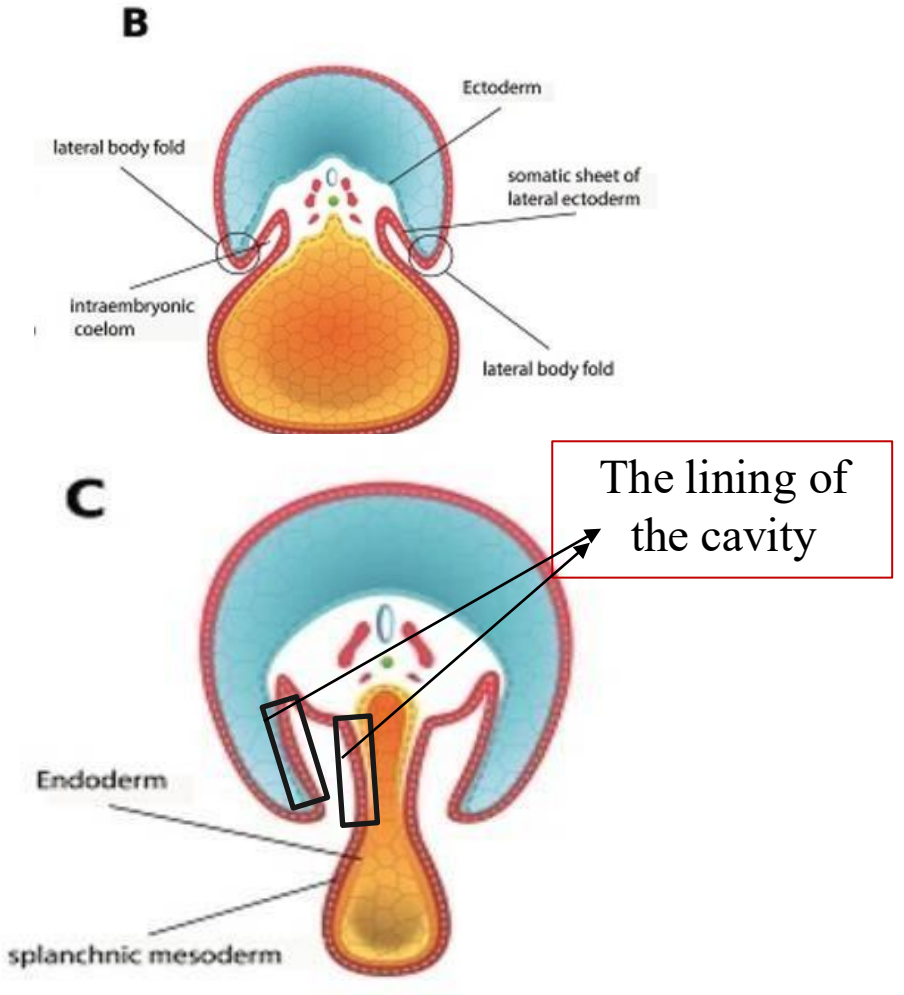
Recall from introductory embryo, the stages of embryonic development:

- [B] lateral body folds (Transverse fold)

- [C] Yolk sac start diminishing –getting smaller- and pushed into the embryonic body to finally have amniotic cavity surrounding the whole embryo.

- What's important in this stage is to notice how a cavity result from this process appear and is lined by **mesoderm with two origins**:

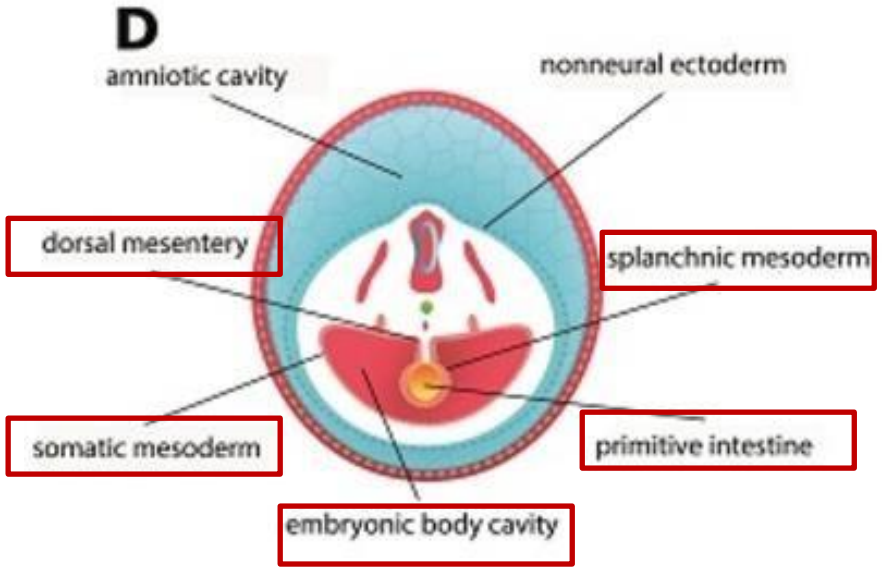
1. **The one that line yolk sac (splanchnic)**
2. **The one that line amniotic cavity (somatic)**



Additional graph

11- Development of the Anterior Abdominal Wall

- ✓ [D] Finally when the transverse fold end, the embryo is cylindrical, the most inner cylinder is the **primitive intestine**.
- ✓ The mesoderm is divided into somatic (from outside) and splanchnic (from inside).
- ✓ Around the primitive intestine there is an **embryonic body cavity** lined by **Somatic Mesoderm** or called **Somatoplueric Mesoderm.**
- ✓ The **primitive intestine** is lined externally by **Splanchnic Mesoderm** or called **Splanchnopleuric Mesoderm.**
- ✓ The connection between these two linings is the **Dorsal Mesentry.**



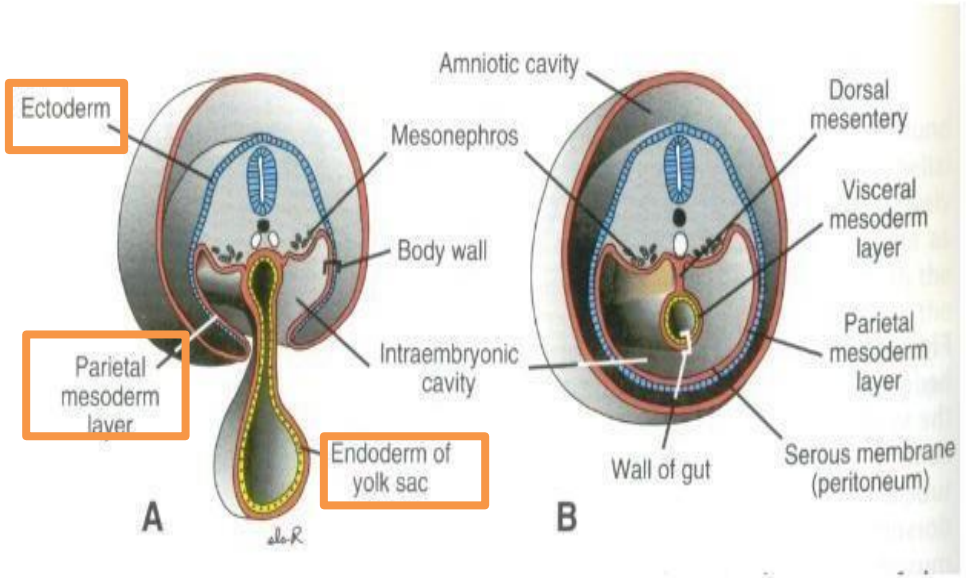
Additional graph

11- Development of the Anterior Abdominal Wall

Lateral Plate Mesoderm Further Divides into Somatopleuric mesoderm and Splanchnopleuric mesoderm.

Somatopleuric mesoderm becomes parietal mesoderm which form serous membranes that line the peritoneal, pleural, and pericardial cavities.

Splanchnopleuric mesoderm becomes visceral mesoderm which form serous membranes that line each organ.



- The **ant. Abdominal wall** is derived from the **somatoplueric mesoderm.**
- The ant. Abdominal wall retain its innervation from the ventral rami of the spinal nerves(including its muscles).
- The somatoplueric mesoderm then tangentially divides into **three layers**:

1. Ext. oblique
2. Int. oblique
3. Trans. Abdominis

- It's also the origin of rectus abdominis muscle.

11- Development of the Anterior Abdominal Wall

Note that:

- ✓ The **Somatic mesoderm** is in contact with **ectoderm** and it gives rise to the **body wall structures** like the ant. Abdominal wall as we said

- ✓ The **splanchnopleuric mesoderm** lies next to the **endoderm** (shown in yellow), and it gives rise to the **internal organ coverings** like the peritoneum, pleura, and pericardium.

Lateral Plate Mesoderm Further Divides into Somatopleuric mesoderm and Splanchnopleuric mesoderm.

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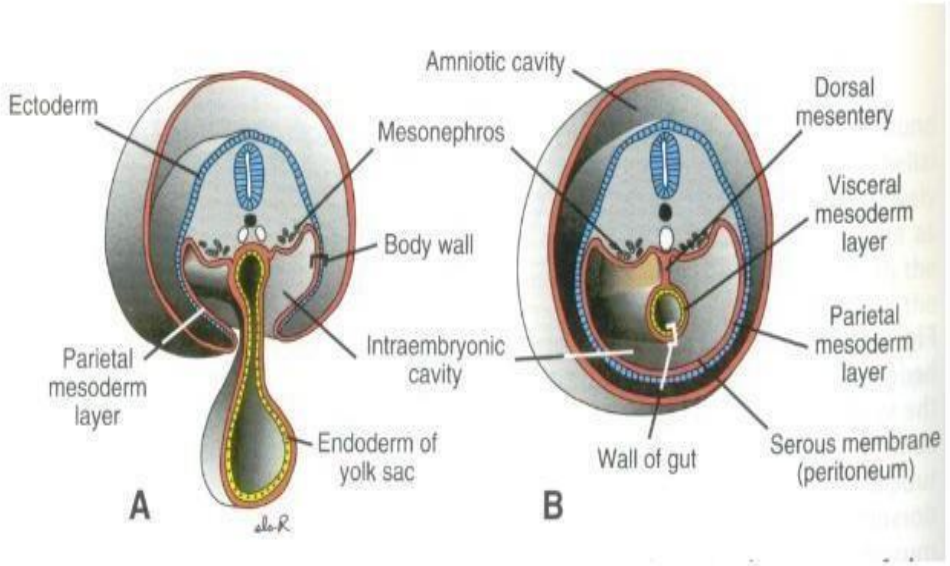
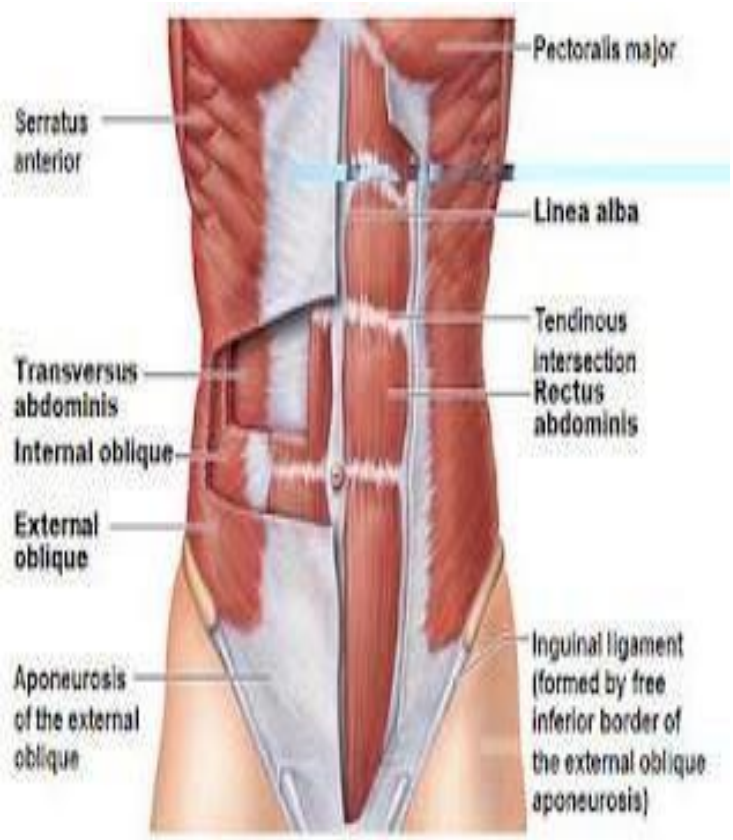


12- Development of the Rectus Abdominis Muscle

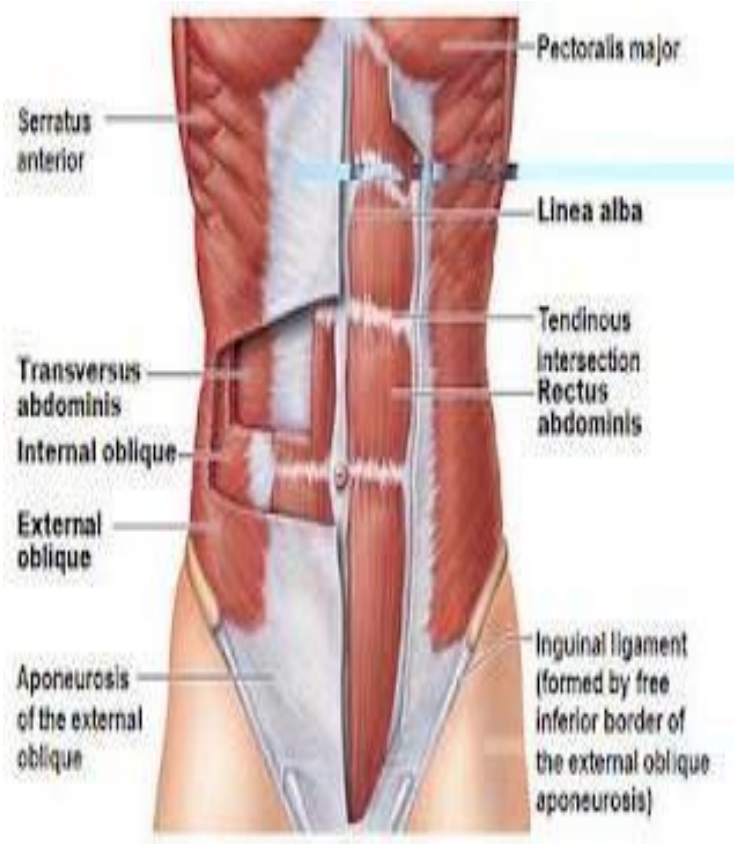
- ✓ The rectus abdominis muscle is derived from the **myotomes**, making it **segmented in origin**.
- ✓ The right and left sides of the muscle <u>start developing separately</u> then at the **3rd month** they fuse together into the midline to form the **linea alpa.**
- ✓ On either side of the lina alpa the rectus muscles lies within their **rectus sheaths**.



12- Development of the Rectus Abdominis Muscle

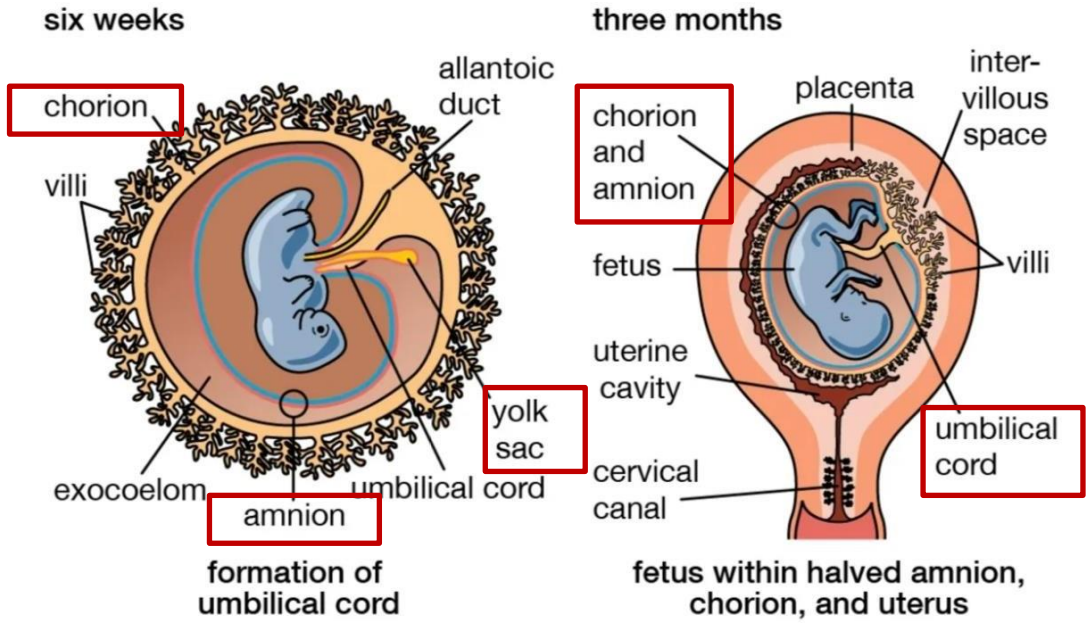
- ✓ Rectus abdominis retains indication of the segmental origin by the presence of **tendinous intersections**.

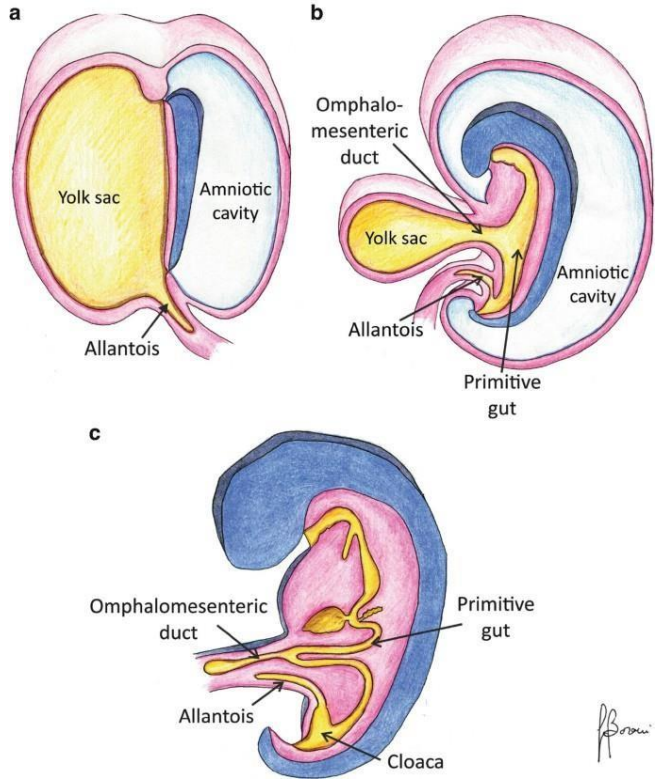
- ✓ The tendinous intersections are **firmly attached Anteriorly** to the rectus sheath, especially in its inferior portion. **This stabilizes the rectus abdominis within its sheath.**



13- Development of the Umbilicus and the Umbilical Cord

- ✓ The amnion and the chorion fuse together.
- ✓ The amnion encloses the body stalk and the yolk sac with their blood vessels to form the tubular umbilical cord.





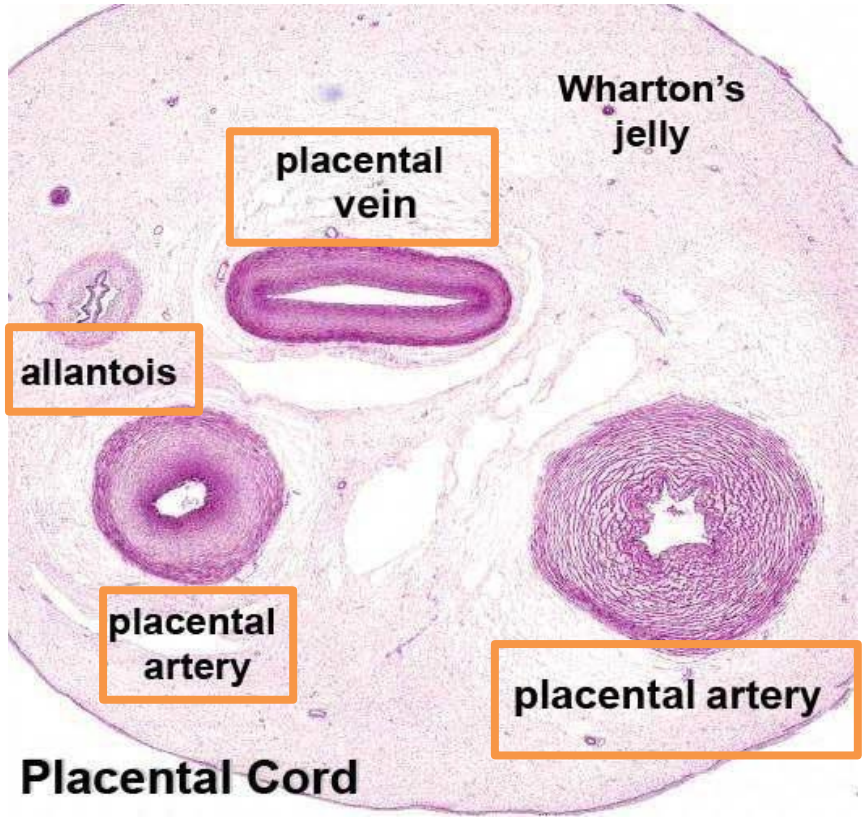
Additional graph

13- Development of the Umbilicus and the Umbilical Cord

- ✓ The umbilical cord is about 45 cm in length, it connects the embryo to the placenta.

- ✓ The mesenchyme core of the cord **(Wharton's jelly)** (Mucoid connective tissue) form a **loose connective tissue** which **embed the following**:

- ✓ Remains of yolk sac
- ✓ Vittelline duct (connected with the Midget)
- ✓ Remains of allantois (was connected with urinary bladder)
- ✓ Umbilical blood vessels
- ✓ Many stem cells



13- Development of the Umbilicus and the Umbilical Cord

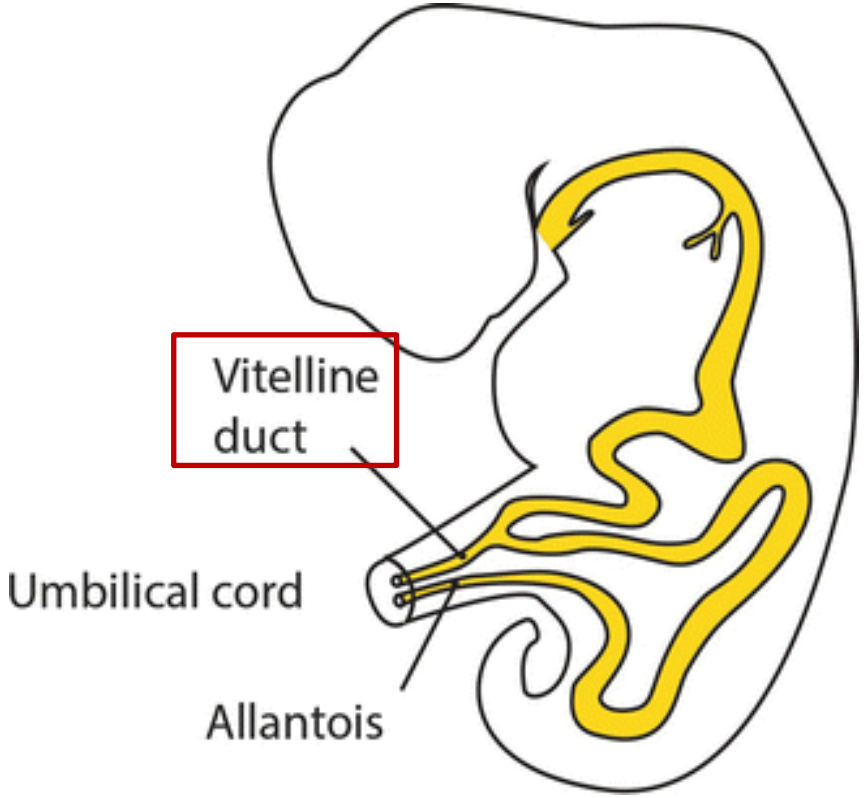
- ✓ Umbilical blood vessels:
- ✓ 2 **arteries** that carries **deoxygenated** blood from the **fetus** to the **chorion (placenta)**
- ✓ 2 **veins** that carry **oxygenated** blood from the **placenta** to **fetus**
- ✓ **The right vein** will soon disappear
- ✓ After birth **the left umbilical vein** will be obliterated and become **ligamentum teres.**

➢ Clinical relation:

The umbilicus cord nowadays is preserved because it contain lots of stem cells, incase the person need it later for any clinical reason.

14- Vitelline Duct Abnormalities

- ✓ The vitelline duct normally connects the midgut to the umbilicus during embryonic development.
- ✓ **Complete obliteration of this duct is essential.**
- ✓ In 2 to 4% of people, a small portion of the vitelline duct persists, forming an outpocketing of the ileum, this condition is called **Meckel's Diverticulum** or ileal diverticulum

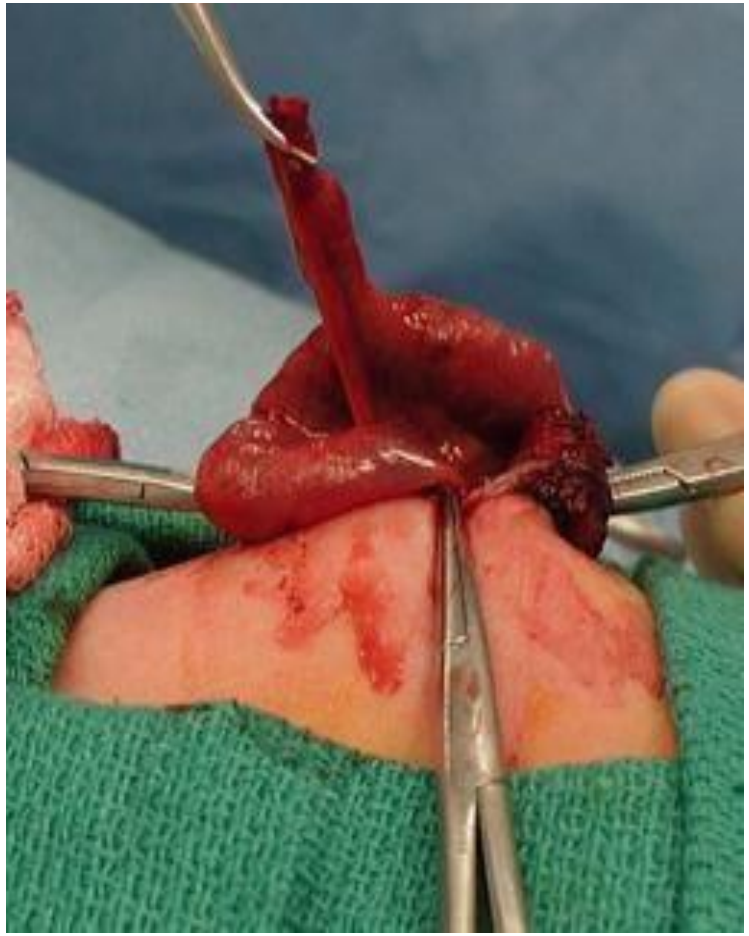


Additional graph

14- Vitelline Duct Abnormalities

- ✓ This diverticulum typically arises around **40–60 cm** (2 feet) **from the ileocecal valve** on the antimesenteric border of the ileum and measures about **2 inches in length**.

- ✓ Usually its asymptomatic ,However, **when it contains heterotopic pancreatic tissue or gastric mucosa**, it may cause **ulceration**, **bleeding**, or even **perforation** and **peritonitis.**

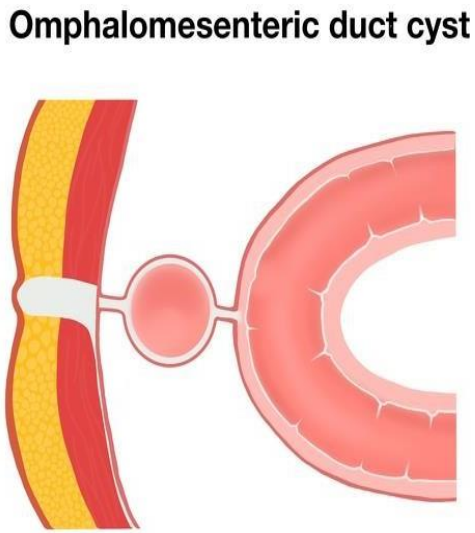


14- Vitelline Duct Abnormalities

- ✓ Sometimes both ends of the vitelline duct transform into fibrous cords, and the middle portion forms a large cyst, an **enterocystoma**, or **vitelline cyst.**

- ✓ This type of anomaly typically forms around the **2nd to 3rd month** of gestation.

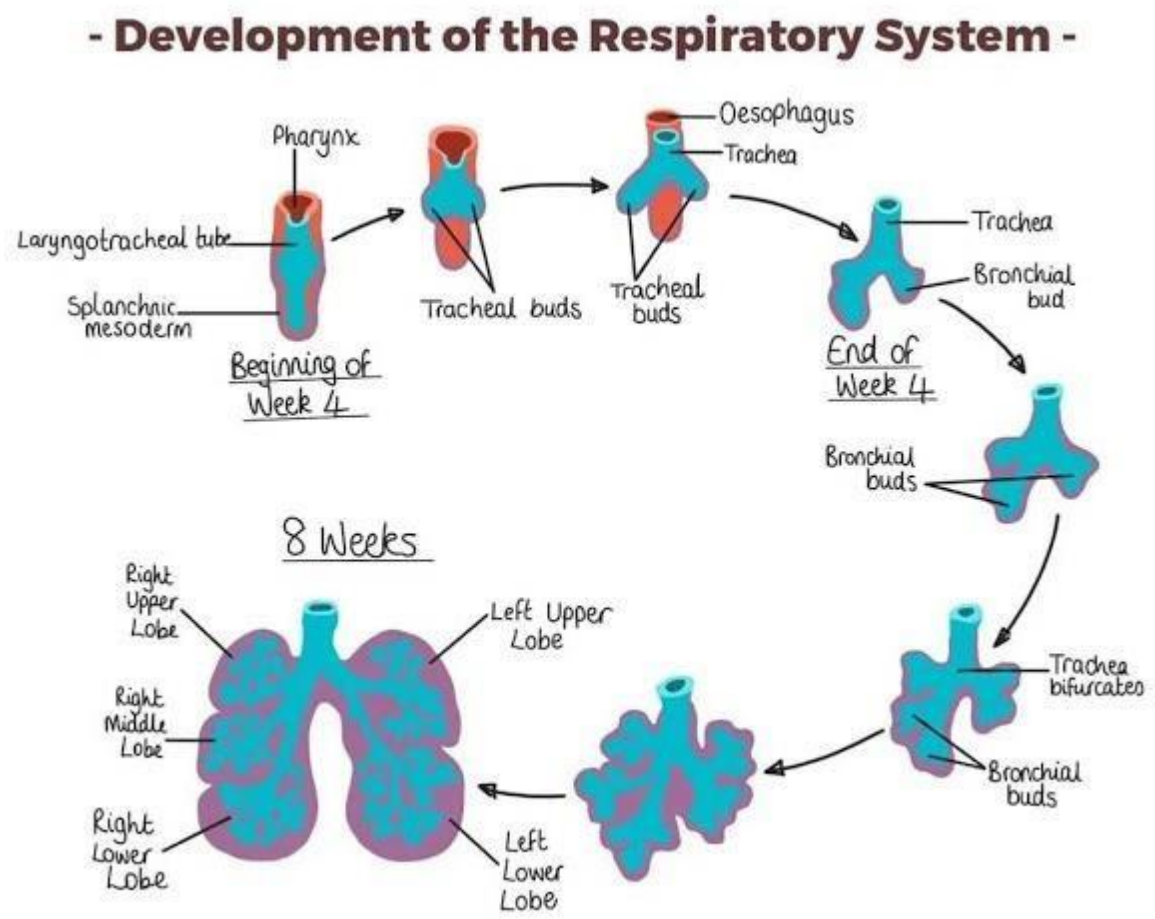
- ✓ In most cases, a vitelline cyst does not cause clinical problems, and it is usually considered a minor anomaly **unless it becomes infected or enlarged.**



Additional graph

15- Formation of the Lung Buds

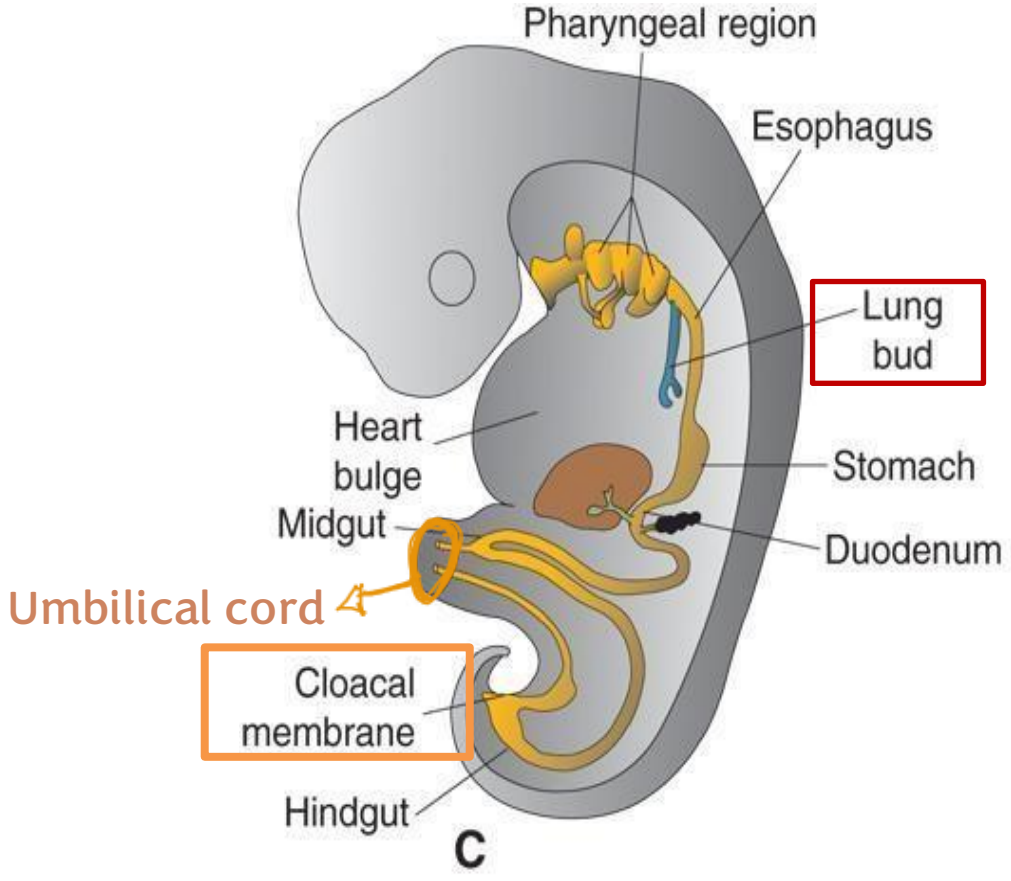
- ✓ At the **4th week** , the respiratory diverticulum (lung bud) appears as an <u>outgrowth from the ventral wall of the foregut.</u>
- ✓ The location of the bud along the gut tube is determined by signals from the surrounding mesenchyme, including **fibroblast growth factors (FGFs)** that "instruct" the endoderm.
- ✓ The lung bud **gives rise to** the **trachea, bronchi, bronchioles, and lungs.**



Additional graph

15- Formation of the Lung Buds

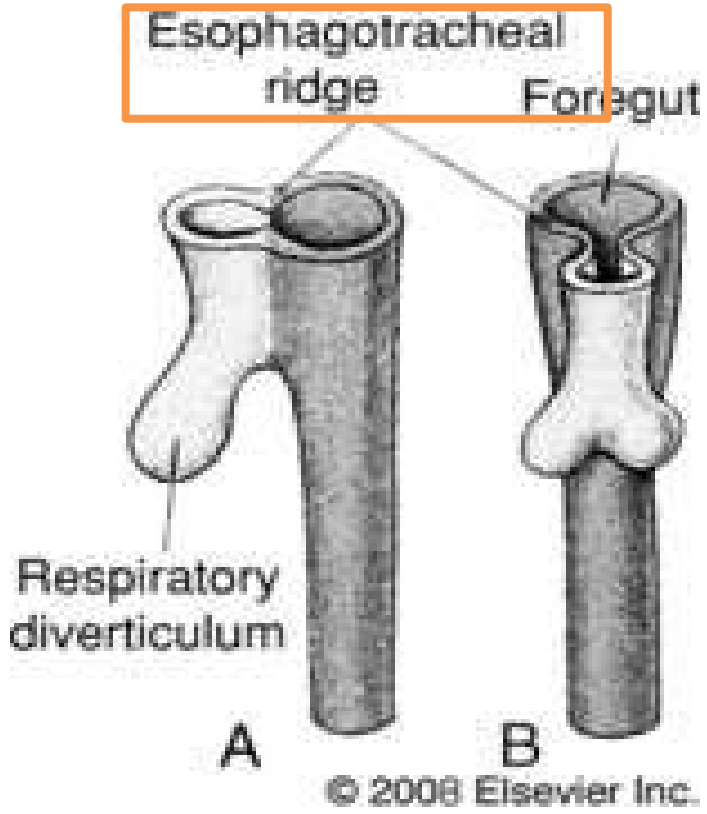
- ✓ Hence epithelium of the internal lining of the larynx, trachea, and bronchi, as well as that of the lungs, is entirely of **endodermal origin**.
- ✓ The cartilaginous, muscular, and connective tissue components of the trachea and lungs are derived from **splanchnic mesoderm** surrounding the foregut.



6-1C Lung bud initiation and branching

15- Formation of the Lung Buds

- ✓ Initially the lung bud is in open communication with the foregut.
- ✓ As the foregut elongates downward, it also gives rise to the esophagus. Meanwhile, the respiratory diverticulum **buds off**.
- ✓ A crucial step is the separation between the esophagus and lung bud, with **the epiglottis remaining as the only opening to the developing larynx and airway**.



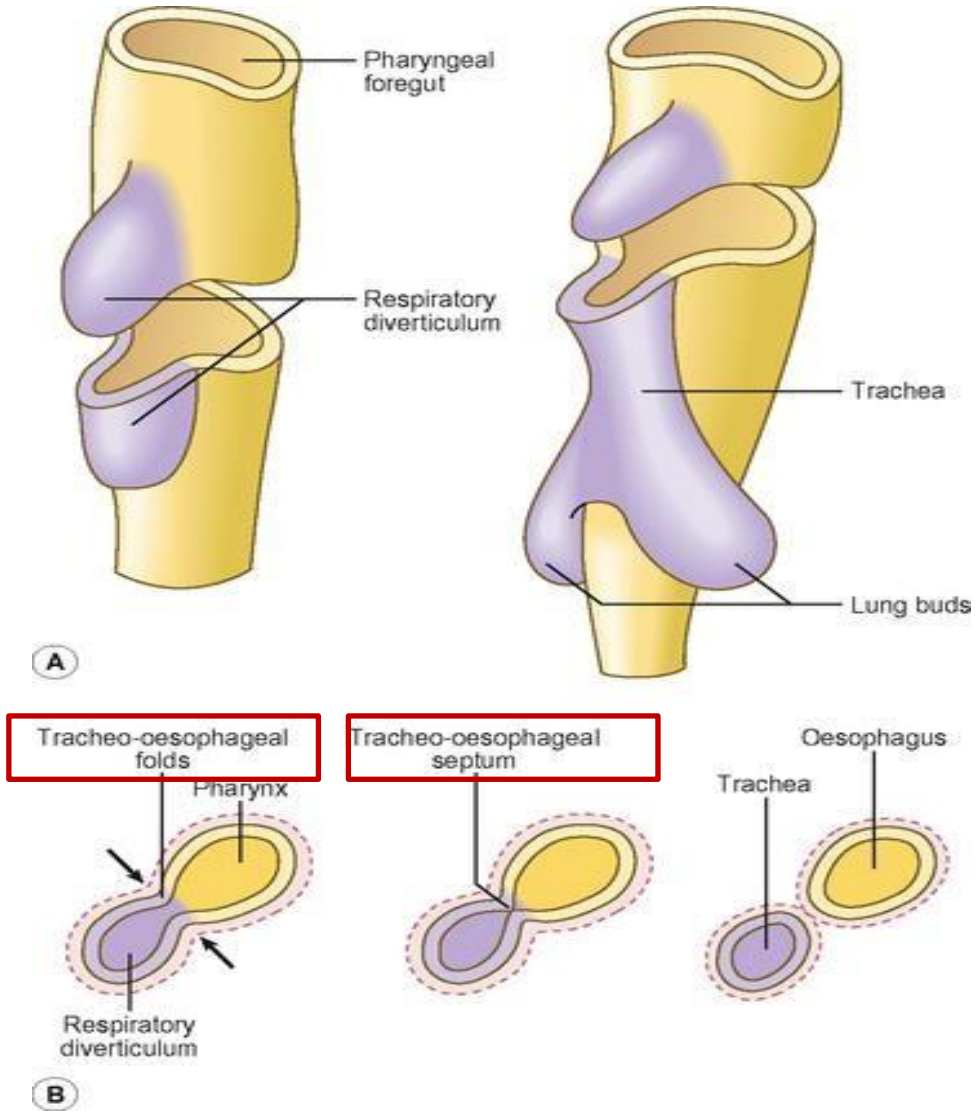
15- Formation of the Lung Buds

- ✓ When the diverticulum expands caudally, however, two longitudinal ridges, **the tracheoesophageal ridges**, separate it from the foregut ,the ridges keep growing medially.

- ✓ Subsequently, when these ridges fuse to form the **tracheoesophageal septum**, the foregut is divided into a **dorsal portion, the esophagus**, and a **ventral portion, the trachea and lung buds** , ech of them then will develop separately.

- ✓ The respiratory primordium maintains its communication with the pharynx through the **laryngeal orifice.**

Additional graph



Some parts of the lecture is supported with external short animations, whenever you see the logo of Osmosis.org , click on it . (Unsponsored)

GI embryology 2

Index

1-The normal development of the esophagus

Recall that we ended the last lecture by lung budding from the foregut; hence, we can say that the respiratory system arises from the gastrointestinal tract.

- ✓ As we know, the foregut includes the esophagus, the stomach, and the duodenum down to the major duodenal papilla.
- ✓ The picture A shows a ridge between esophagus and trachea.
- ✓ In picture B , tracheoesophageal septum begins to form.
- ✓ In picture c, the trachea and the esophagus are fully separated.

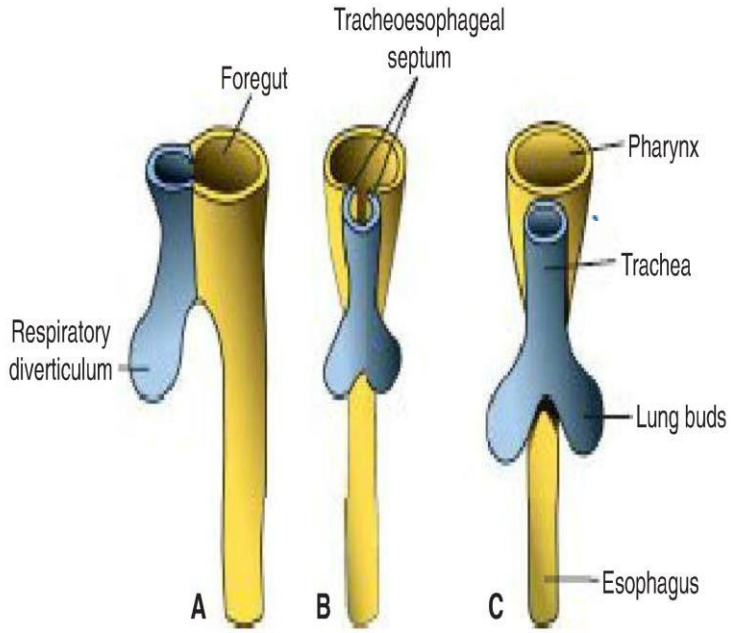


FIGURE 15.6 Successive stages in development of the respiratory diverticulum and esophagus through partitioning of the foregut. **A.** At the end of the third week (lateral view). **B,C.** During the fourth week (ventral view).

- ✓ However, abnormalities during the esophagus development can occur, resulting in many conditions which will be discussed in the next slide including: Esophageal atresia +/ - tracheoesophageal fistula, Hiatal hernia, stenosis.

Check me!
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2:10–>3:00

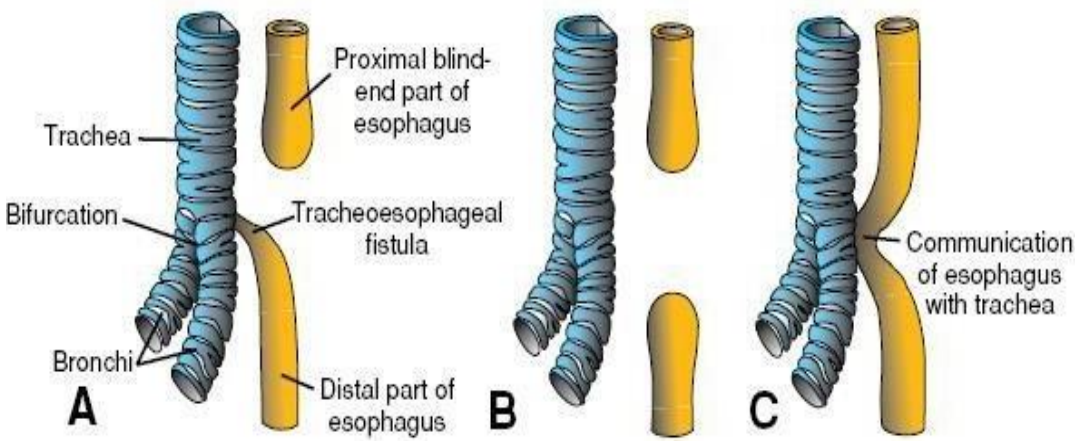
2-Esophageal Abnormalities

- ✓ If the **tracheoesophageal septum fails to separate**, the fetus will develop esophageal abnormalities, which can manifest as **atresia** (an uncanalized tube=a blind-ended sac), **fistula** (a connection between the esophagus and the respiratory tract-most common at the site of trachea bifurcation), **or both**.

A) Proximal Esophageal **Atresia** with **distal** Tracheoesophageal **Fistula** – occurs in 90% of cases **(most common).***

B) Double Blind end sac – both **proximal and distal** esophageal **atresia** (no communication, no fistula) (in 4% of the cases).

C) H-shaped fistula,**Fistula only** – a communication between the trachea and esophagus **without atresia**. (In 4% of the cases)



**Editor's Note: We know that the doctor mentioned the case A to be only in 4% of the cases in the recorded lecture on JU medicine ; however, this year's lecture in sections other than the one in which it was recorded, the textbook, as well as the last year's modified says it's as common as 90%, so don't worry, the editor has got your back!*

2-Esophageal Abnormalities

D) Distal atresia with **proximal fistula**. (In 1% of the cases)
E) Double fistula with **no atresia**. (In 1% of the cases)

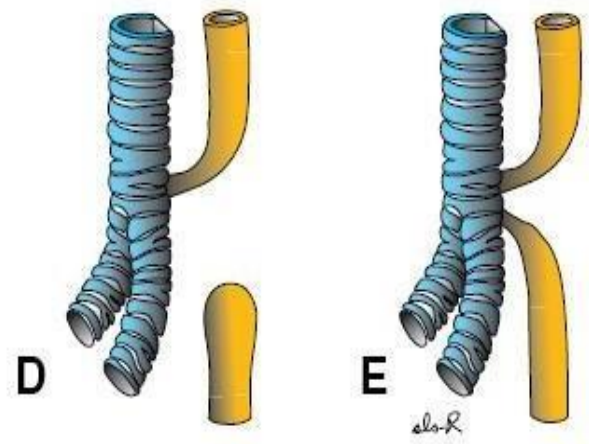
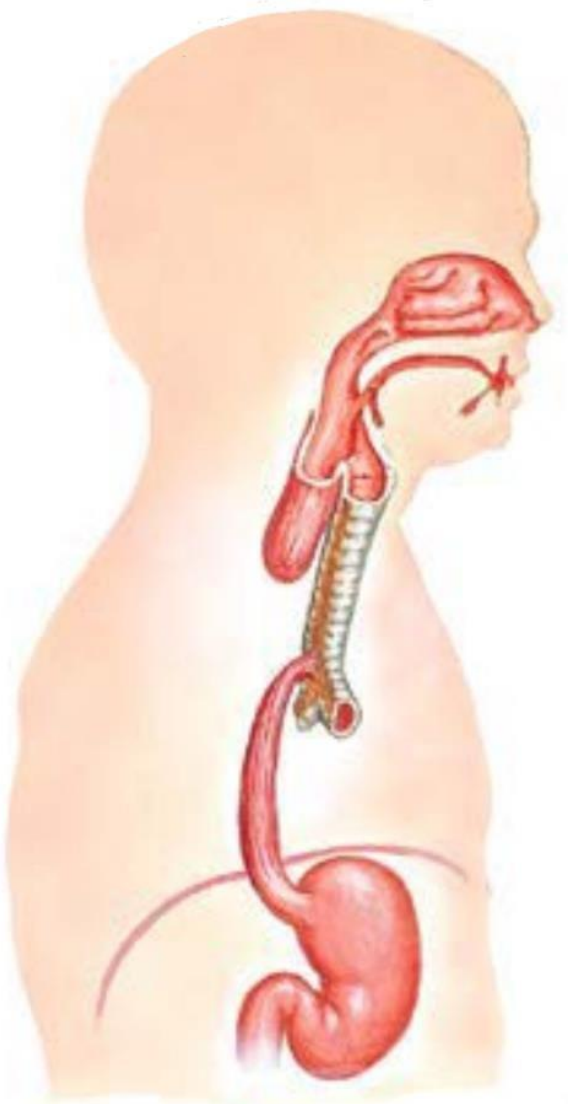


Figure 13.7 Variations of esophageal atresia and/or tracheoesophageal fistula in order of their frequency of appearance: **A,** 90%; **B,** 4%; **C,** 4%; **D,** 1%; and **E,** 1%.

2-Esophageal Abnormalities



Extra figure

- ✓ The **clinical consequences** of esophageal abnormalities:
  we will take case A in which there is a **proximal atresia and distal fistula** (the most common case scenario):
  Soon after birth you can notice (postnatal manifestations):
  1) During breastfeeding, instead of swallowing the milk into its normal route from the mouth to the stomach passing through the esophagus, the swallowed milk will face a dead end where the **esophagus is closed** (blind end pouch = proximal atresia), so **what goes in**, **comes back out** into the mouth.
  2) As a result of the **fistula**, air enters the stomach, so every time the baby cries, the baby's belly **becomes bloated as the stomach is filled with air**.
  3) The **fistula** may also cause **gastric contents regurgitation into the lungs** causing acute **pneumonia** which can develop into chronic pneumonia if left untreated.

2-Esophageal Abnormalities

- ✓ You may ask yourself: Can't we detect this congenital abnormality before birth? The answer is yes, we absolutely can.(Prenatal manifestation)

  During routine fetal development checks, the obstetrician measures the amount of amniotic fluid in the amniotic sac surrounding the fetus. The fetus urinates into the amniotic fluid, swallows it, and then urinates again into the amniotic fluid creating a continuous cycle.The level of amniotic fluid should remain within a normal range. If the amount increases beyond normal, the condition is called **polyhydramnios**.

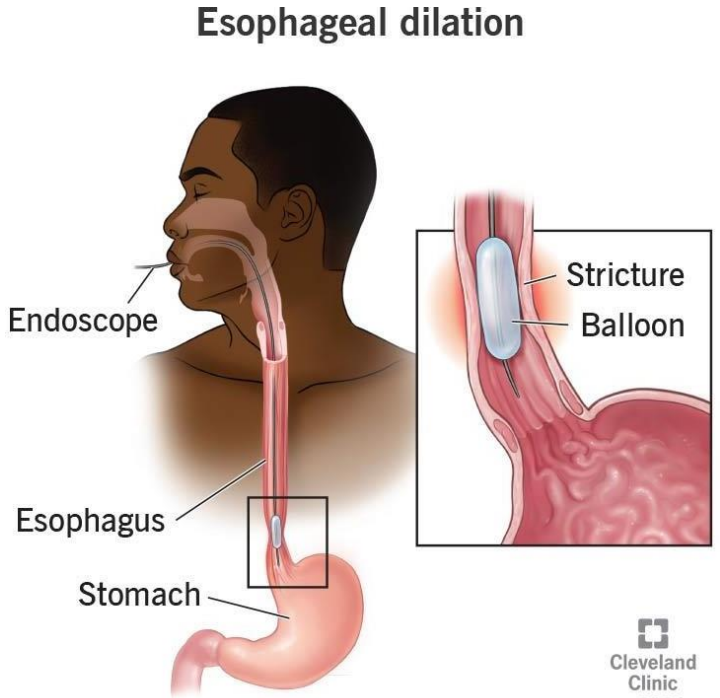
  4)**One of the causes** of **polyhydramnios** is **proximal esophageal atresia with distal tracheoesophageal fistula**, in which the total pool of the amniotic fluid is in the amniotic sac (unlike in normal cases in which the fluid is divided between the amniotic sac and the fetus).

- ✓ Treatment: **surgical correction** after birth of the esophageal abnormality as soon as possible.
- ✓ In clinical cases such as a Tracheoesophageal Fistula (TEF), it is often associated with other congenital abnormalities, particularly cardiac defects like Tetralogy of Fallot, Ventricular Septal Defect (VSD), and Atrial Septal Defect (ASD)."

2-Esophageal Abnormalities

- ✓ Since the esophagus is a narrow tube that descends downward toward the stomach as a result of the crowding in the chest cavity that contains the pericardium, the heart, and the lungs, all of these structures applies pressure on the esophagus, pushing it downward further and causing the esophagus to elongate downward into the abdomen.

- ✓ Sometimes **stenosis** occurs, especially in the **lower third** of the esophagus (abdominal esophagus) where it perforates the diaphragm in its way to the stomach , so when the patient eats, most of the food is regurgitated and only a small fraction reaches the stomach, fortunately, a minor outpatient procedure can be applied to relieve **(dilate)** the stenosed area.



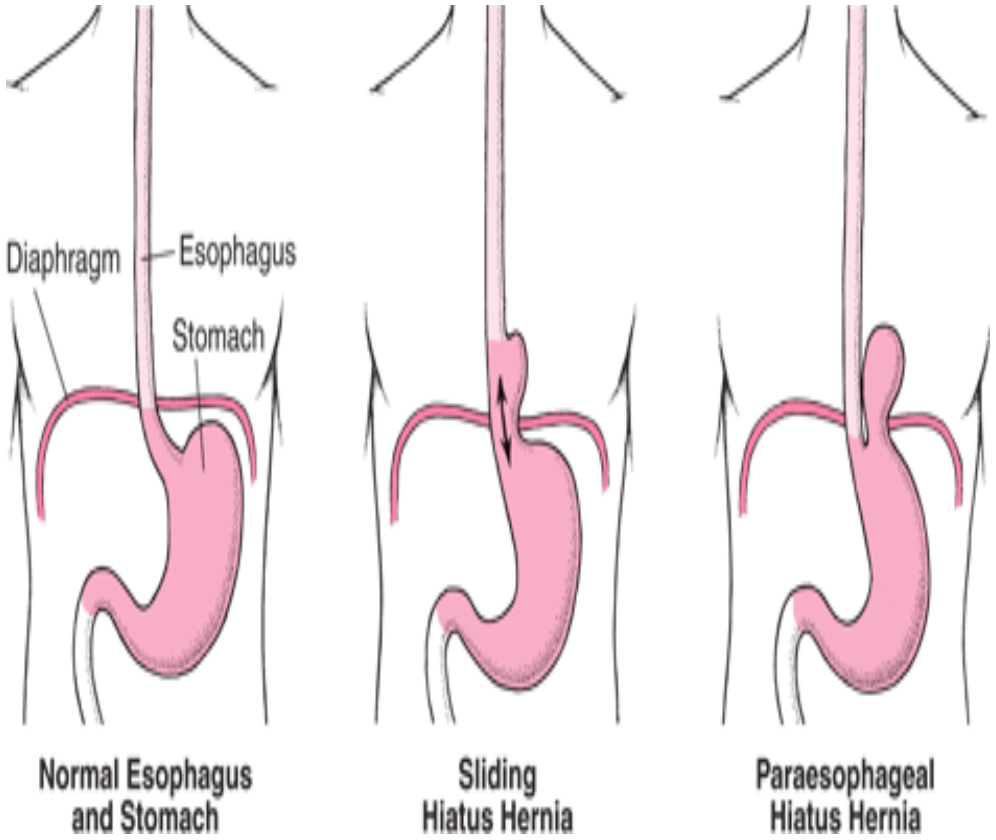
Extra figure

2-Esophageal Abnormalities

✓ The third esophageal abnormality is the **congenital hiatal hernia**.

✓ The hiatal hernia can be either classified as :

1) **Sliding hiatal hernia** (a portion of the stomach protrudes upward through the diaphragm (through the esophageal hiatus).
2) **Paraesophageal hiatal hernia** which involves the upper part of the stomach bulging alongside -parallel to - the esophagus.



3- Stomach Embryogenesis

- ✓ The **stomach** is considered a **fusiform*** shaped with proximal and distal openings in the early embryonic stages. (At the fourth week of development).
- ✓ To ease the learning process, we will study the **transformation** of the fusiform stomach to the mature one (the stomach which has 2 surfaces, 2 boarders and 2 curvatures) **around 2 axes**, **a vertical axis** (crosses the 2 openings of the fusiform) and **an anteroposterior axis.**
- ✓ During the following weeks, its appearance and position change greatly as a result of the **different rates of growth** in various regions of its wall and the changes in **position of surrounding organs.**

** The term "fusiform" describes something shaped like a spindle, meaning wide in the middle and tapering towards the ends*

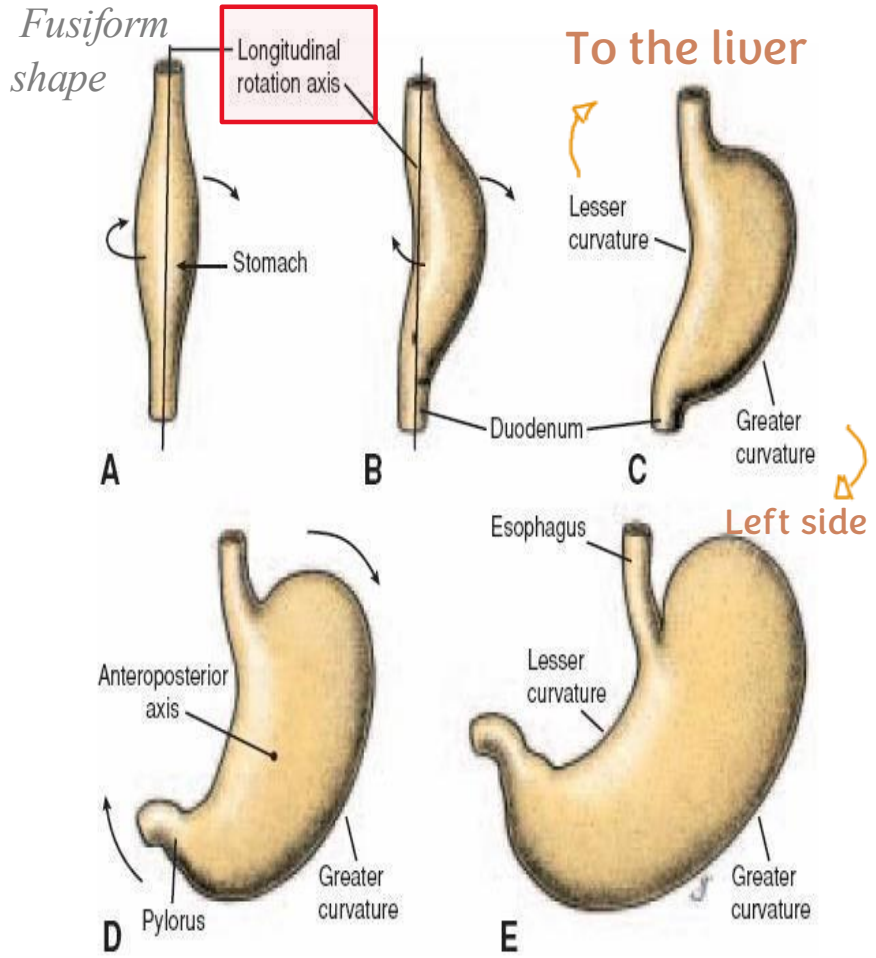
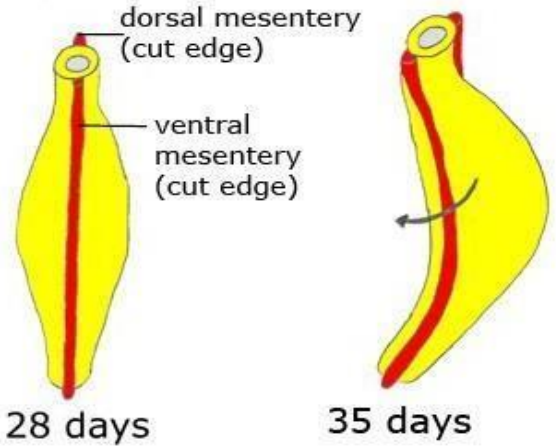


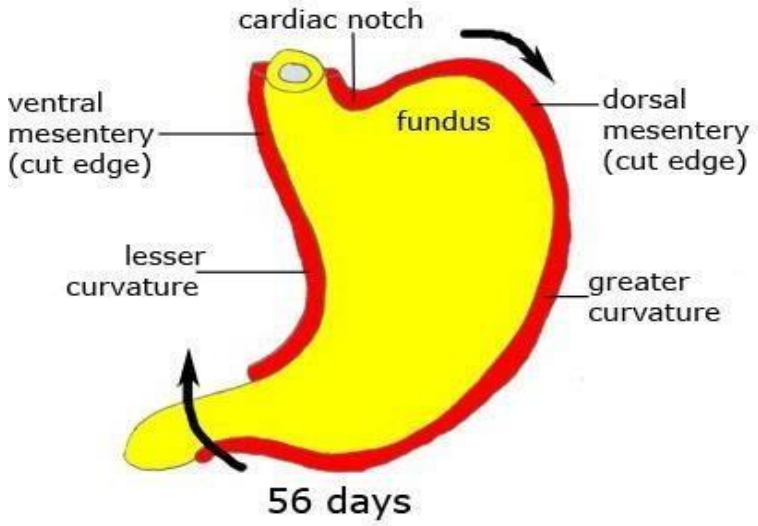
Figure 13.8 A, B, and **C.** Rotation of the stomach along its longitudinal axis as seen anteriorly. **D** and **E.** Rotation of the stomach around the anteroposterior axis. Note the change in position of the pylorus and cardia.

3- Stomach Embryogenesis

- ✓ During the stomach development, **90 degrees clockwise rotation** occurs around the **longitudinal axis** , this causes the **original left side becomes anterior** and the **right side becomes posterior.**
- ✓ As a result, the **left vagus** nerve will innervate the **anterior wall** of the stomach and the **right vagus** nerve will innervate the **posterior wall.**



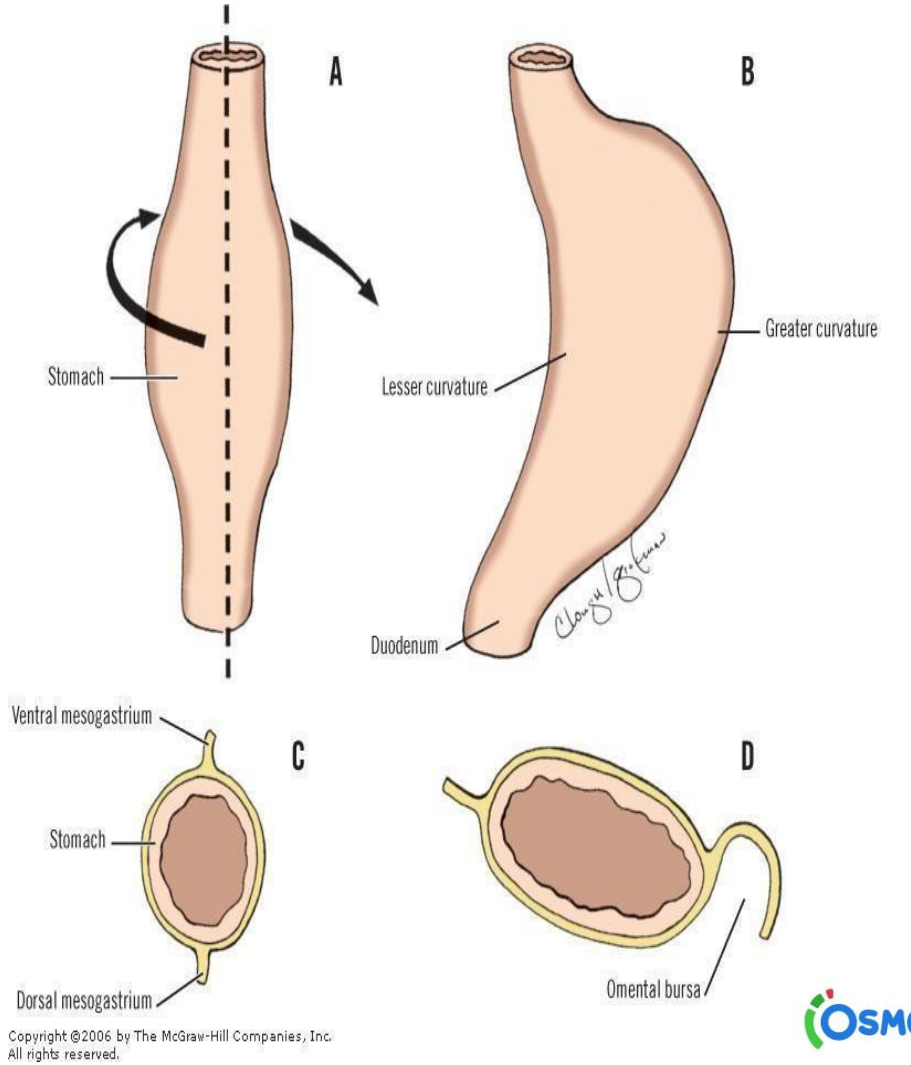
- ✓ The **posterior surface** (which will shift to the left after the rotation) exhibits **rapid growth** in contrast to the anterior one , forming the **greater curvature**, while the **slower growing anterior side** (which will shift to the right) forms the **lesser curvature.**



- ✓ The lesser sac forms behind the stomach as a result of stomach rotation.

3- Stomach Embryogenesis

- ✓ The cephalic (cardiac portion) and caudal (pyloric portion) ends of the stomach are **originally** located in the **midline** (both are crossed by the longitudinal axis in the **fusiform stage**).
- ✓ However, during development, the stomach **rotates** around **anteroposterior axis** such that the **cardiac** part moves **downward** and to the **left** while the **pyloric** part moves **upward** and to the **right**, decreasing the distance between the two ends .



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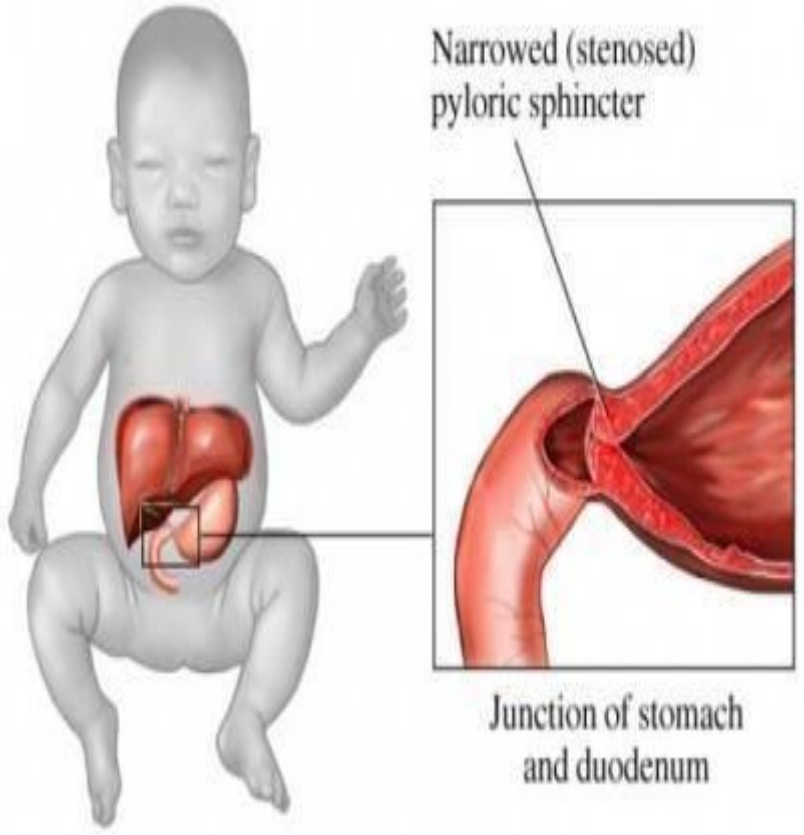
3:00–>5:20

4-Stomach Abnormalities

- ✓ **Pyloric stenosis** (pyloric hypertrophy)

  occurs when there is a thickening of the inner layer of the smooth muscle of the pyloric sphincter causing it to close. As a result, the baby experiences **projectile vomiting** (vomiting with force), fortunately, it can be surgically corrected.



5- The dorsal and Ventral Mesentery

- ✓ Initially the foregut, midgut, and hindgut are in broad contact with the mesenchyme of the posterior abdominal wall .
- ✓ By the fifth week however, the connecting tissue bridge has narrowed, and the caudal part of the foregut, the midgut, and a major part of the hindgut are suspended from the abdominal wall by the dorsal mesentery the dorsal mesentery extends from the lower end of the esophagus to the cloacal region of the hindgut.

- ✓ In the region of the **stomach** it forms the **dorsal mesogastrium** or **greater omentum;** in the region of the duodenum it forms the dorsal **mesoduodenum**; and in the region of the colon it forms the **dorsal mesocolon**.

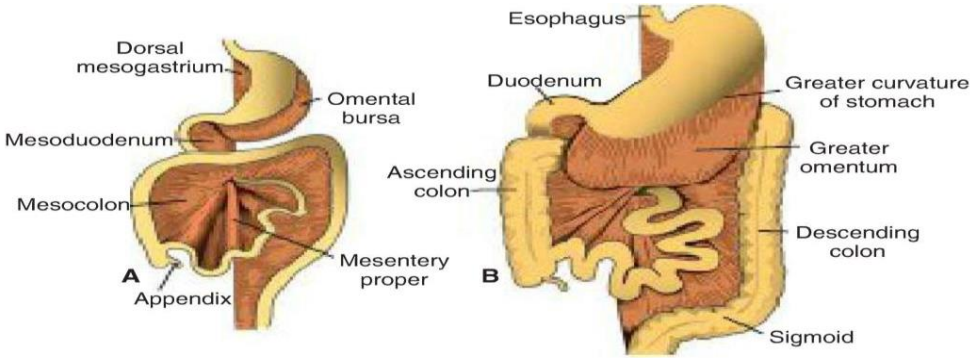
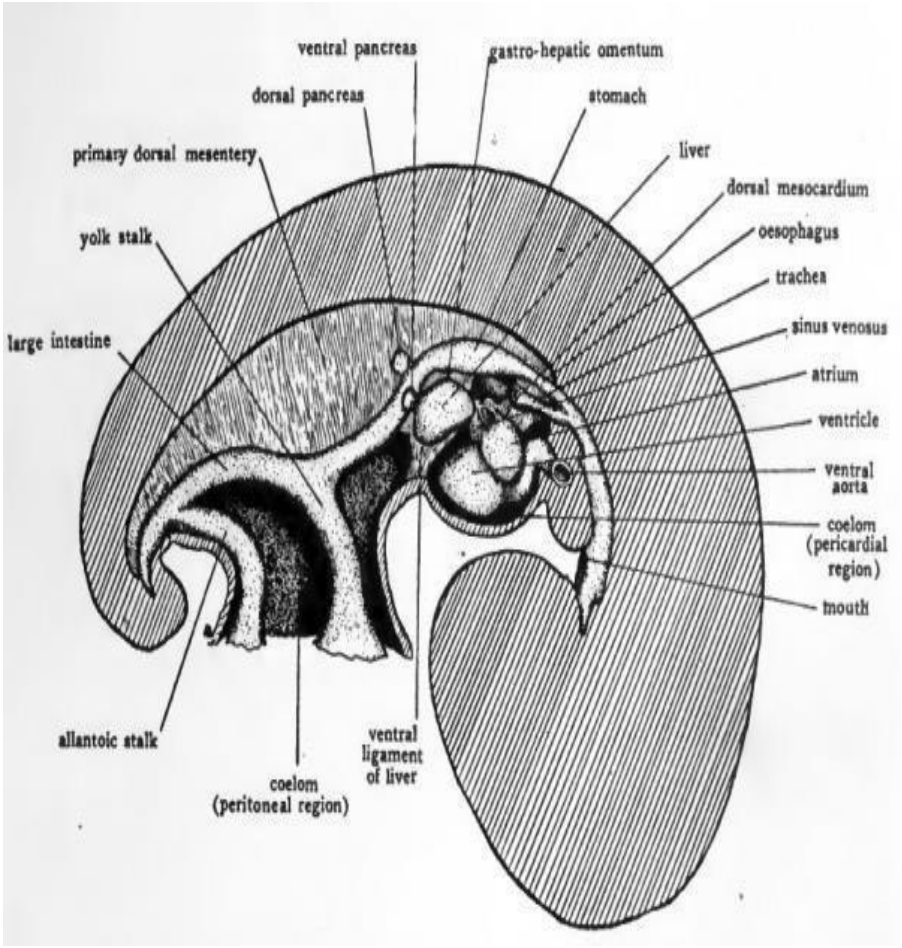


FIGURE 15.12 **A.** Derivatives of the dorsal mesentery at the end of the third month. The dorsal mesogastrium bulges out on the left side of the stomach, where it forms part of the border of the omental bursa. **B.** The greater omentum hangs down from the greater curvature of the stomach in front of the transverse colon.

- ✓ The dorsal mesentery expands from the greater curvature of the stomach and fuses with the posterior abdominal wall. It disappears where it overlies retroperitoneal organs such as the duodenum, pancreas, kidneys, and the great vessels (Aorta and IVC). Ultimately, this structure hangs down to form the greater omentum.

5- The dorsal and Ventral Mesentery

- ✓ **Ventral mesentery,** goes right and upwards which includes the **lesser omentum** (including the hepatodoudenal and hepatogastric ligaments) as well as other **liver ligaments** (falciform ligament, coronary ligaments as well as the triangular ligaments of the liver) **forms from the ventral mesogastrium**, which itself is derived from mesoderm of the septum transversum.
- ✓ Notice that all the ligaments of the liver arises from the ventral mesogastrium, **except ligamentum teres** which results from the obliteration of the umbilical vein.



6- Mesogastrium Formation

- ✓ The stomach is attached **posteriorly** to the dorsal body wall by the **dorsal mesogastrium** and **anteriorly** to the ventral body wall by the **ventral mesogastrium** (in the fusiform stage).

- ✓ **Rotation** around the **longitudinal axis** pulls **the dorsal mesogastrium** to the **left** (12 to 3 o'clock rotation), creating a space behind the stomach called the **omental bursa (lesser peritoneal sac).**

- ✓ This **rotation** also pulls **the ventral mesogastrium** to the **right** (6 to 9 o'clock rotation)**.**

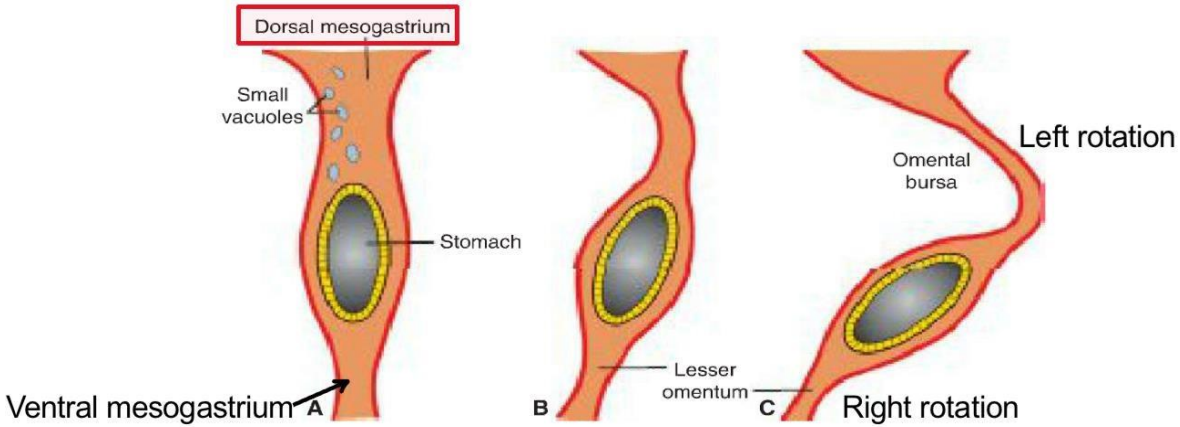


FIGURE 15.9 **A.** Transverse section through a 4-week embryo showing intercellular clefts appearing in the dorsal mesogastrium. **B,C.** The clefts have fused, and the omental bursa is formed as an extension of the right side of the intraembryonic cavity behind the stomach.

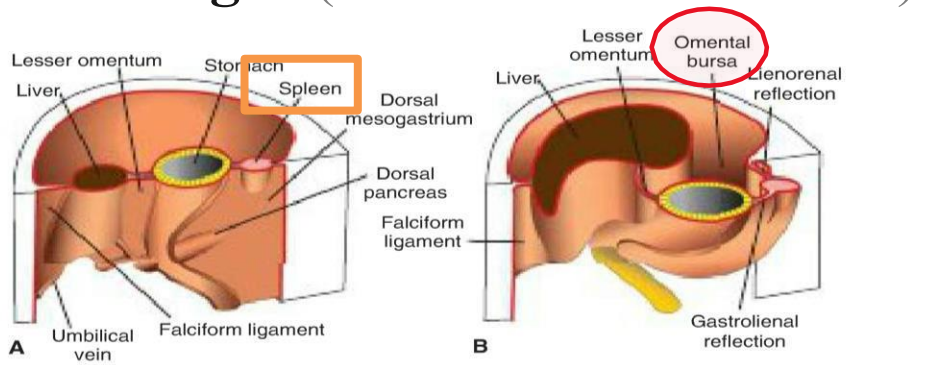


FIGURE 15.10 **A.** The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa (lesser peritoneal sac).

- ✓ As we see in the picture, when the stomach rotates, the **lesser sac** is formed **behind the stomach**.

6- Mesogastrium Formation

- ✓ The **dorsal mesogastrium** lengthens to the left, forming:
  1) The spleen. Proliferation of mesoderm forms the spleen and its ligament
  2) Gastrosplenic (Gastrolienal) ligament.
  3) Lienoranal ligament. With the left kidney

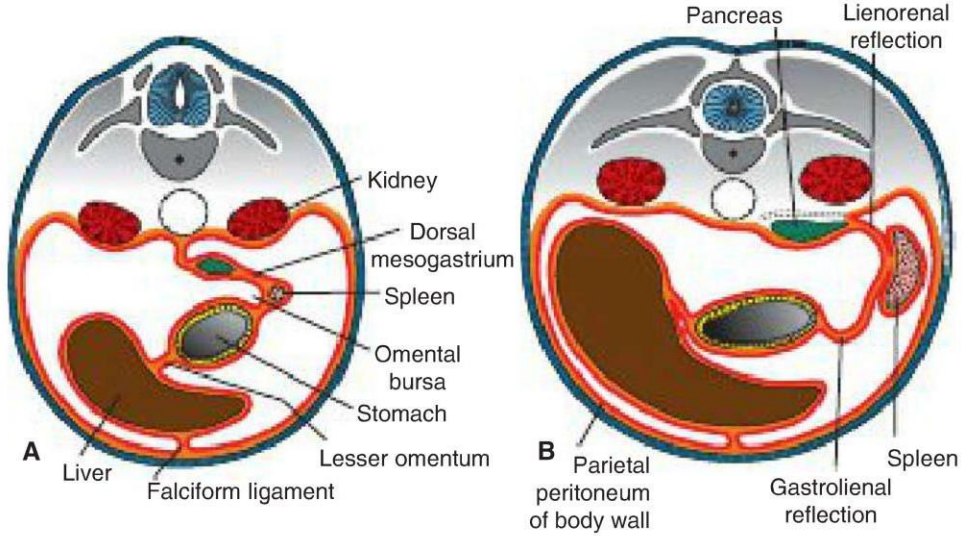
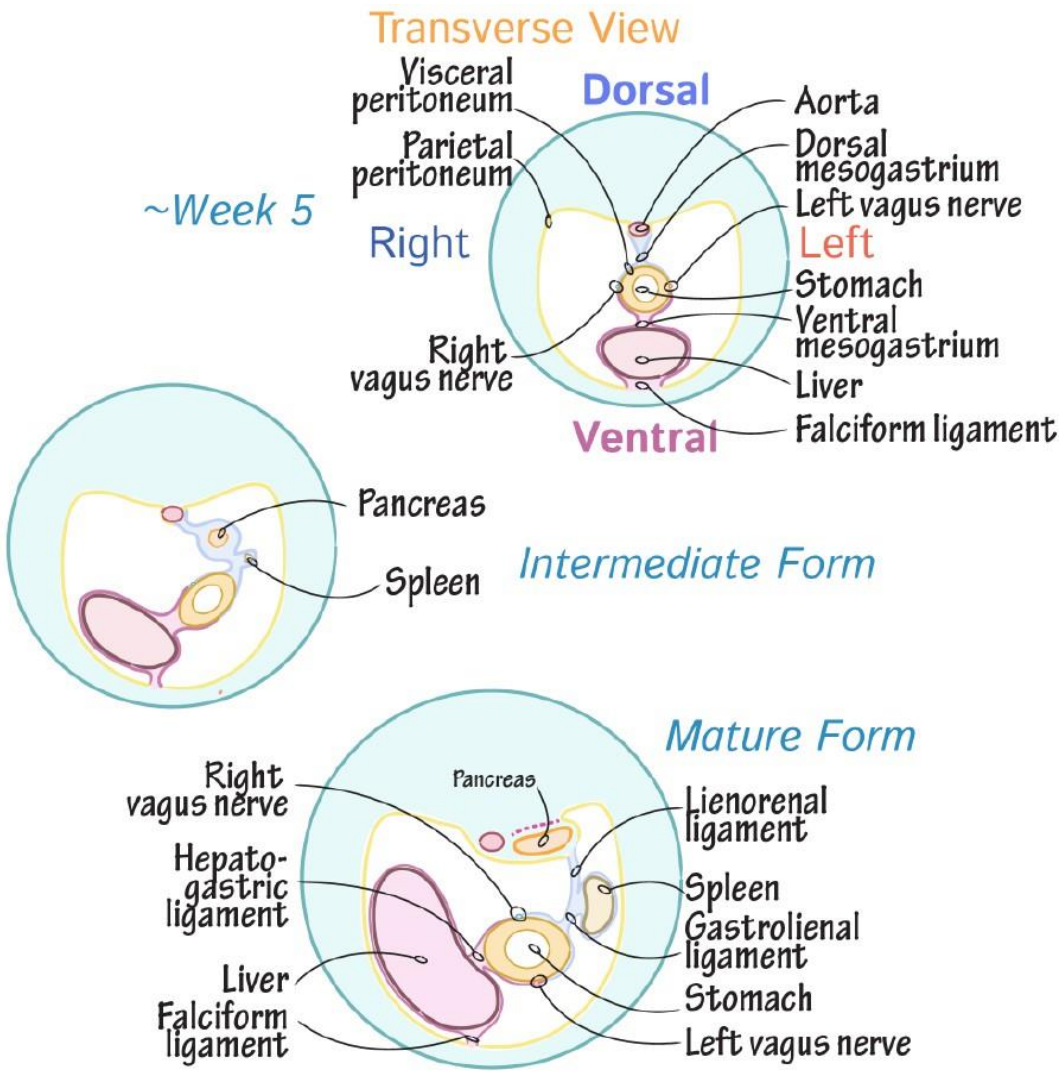


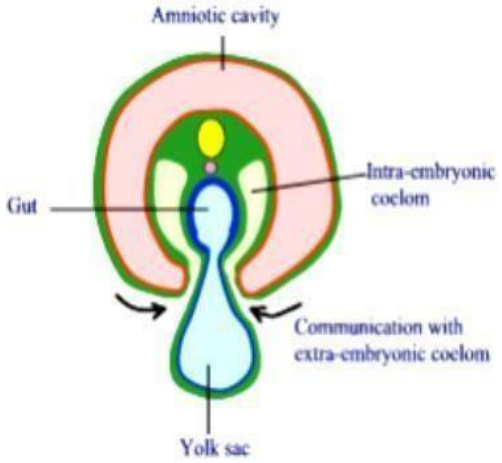
FIGURE 15.11 Transverse sections through the region of the stomach, liver, and spleen, showing formation of the omental bursa (lesser peritoneal sac), rotation of the stomach, and position of the spleen and tail of the pancreas between the two leaves of the dorsal mesogastrium. With further development, the pancreas attaches to the posterior body wall.

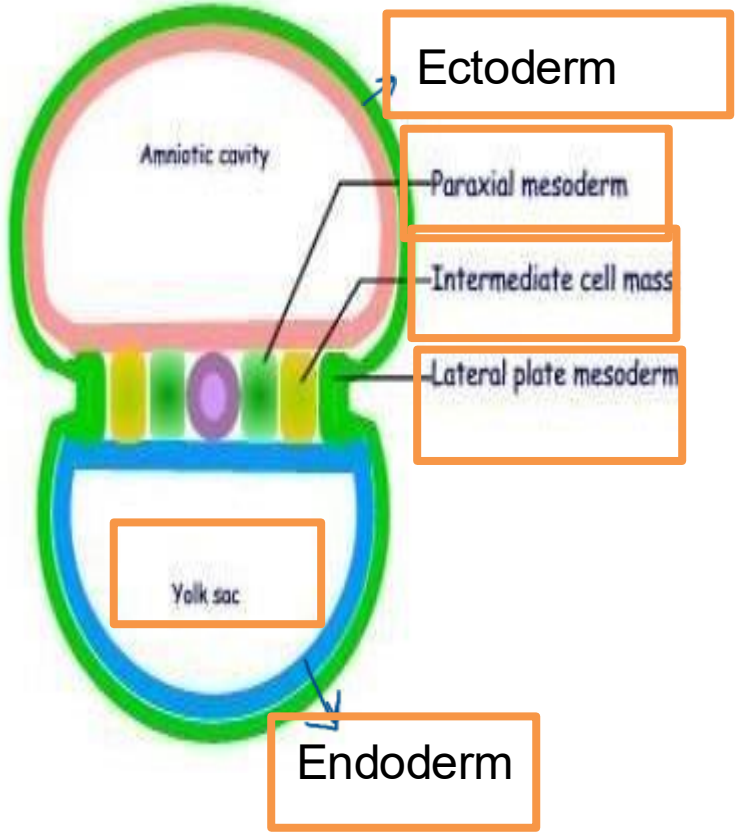


Extra figure

7-Some notes regarding the 3 germ layers

- ✓ An intraembryonic mesoderm on each side of the midline differentiates into a paraxial portion, an intermediate portion, and a lateral plate.
- ✓ When intercellular clefts appear in the lateral mesoderm, the plates are divided into two layers: the somatic mesoderm layer which forms the parietal peritoneum and the splanchnic mesoderm layer which forms the visceral layer of the peritoneum, the latter is continuous with mesoderm of the wall of the yolk sac.
- ✓ As illustrated in the image, the peritoneal cavity is initially open and later it closes.





**Editor's Note 2: This slide is not directly related to the scope of our lecture*

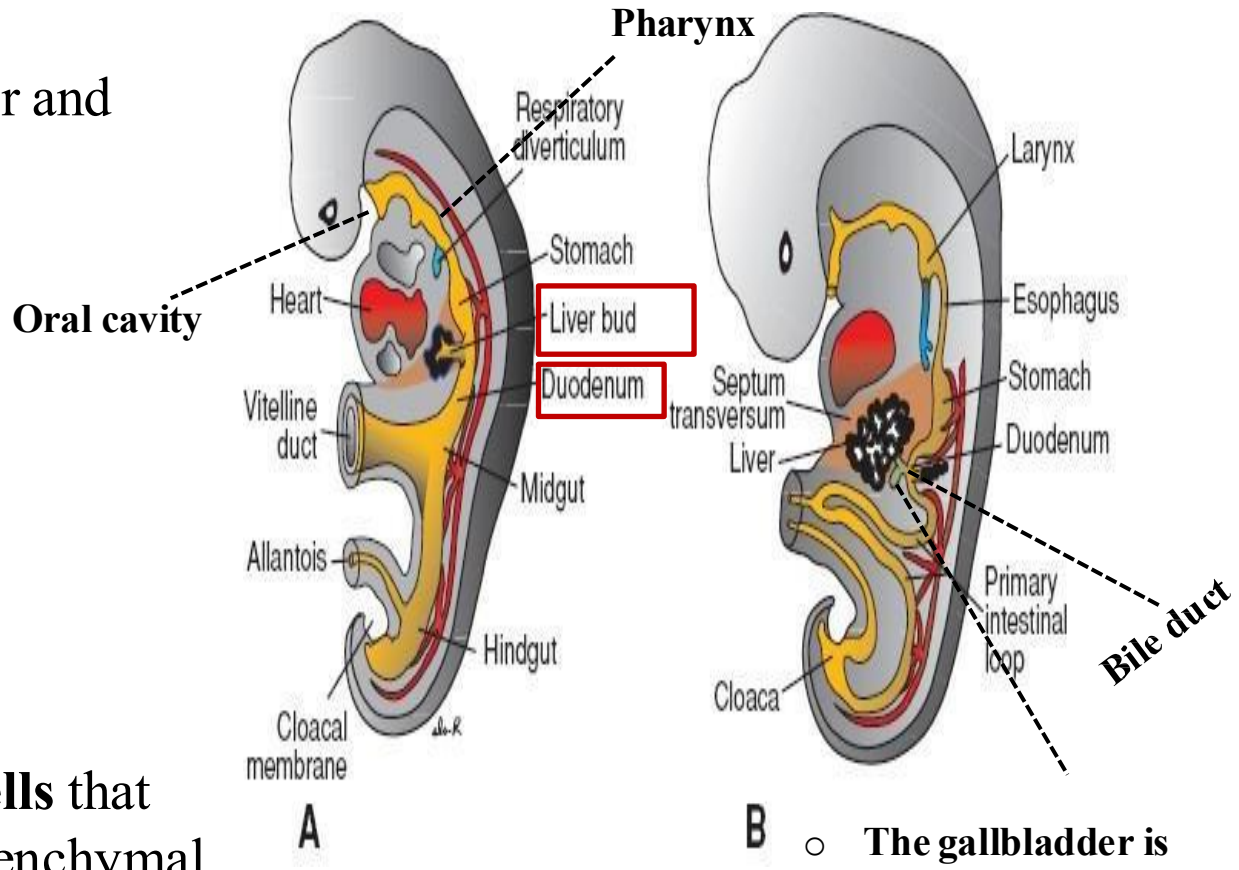
8 -Liver Development

✓ In embryology, the **duodenum** is divided into upper and lower halves:

- The **upper** half is derived from the **foregut**
- The **lower** half originates from the **midgut**

✓ **Liver bud (hepatic diverticulum):**

- Originates as an outgrowth of **endodermal epithelium** of the duodenum.
- Appears at the **junction** between the **upper** and **lower** halves of the **duodenum.**
- This outgrowth consists of **rapidly proliferating cells** that penetrate the **septum transversum** (which is a mesenchymal mesoderm) , lies between the **pericardial** and the **yolk sac** (the liver forms inside the septum transversum).



- **The gallbladder is developed and its cystic duct opens into the common bile duct.**

8 -Liver Development

Do you remember this slide from V0?

- ✓ The doctor explained the parenchyma formation of the liver as follows : "The parenchyma of the liver, which is derived from the mesenchyme of the septum transversum, forms the hepatocytes, the blood sinusoids, capsule of the liver as well as Kupffer cells (with connective tissue origin)."
- ✓ *However, directly quoting from the Langman's Medical Embryology textbook :
  1) "Endoderm forms the epithelial lining of the digestive tract and gives rise to the specific cells (the parenchyma) of glands, such as hepatocytes and the exocrine and endocrine cells of the pancreas." Page 231, chapter 15, 14th edition.
  2) "Hematopoietic cells, Kupffer cells, and connective tissue cells are derived from mesoderm of the septum transversum." Page 241, chapter 15, 14th edition.

- ✓ The umbilical vessels (arteries and veins) together with the vitelline vessels contribute to the formation of the blood sinusoids

**Editor's Note 3: We will check the embryonic origins and the details of this portion of the lecture from the doctor and inform you with the results in V1 inshallah.*

Good to know: One of the embryology past papers questions indicates that the liver develops from all of the following: endoderm of the gut, umbilical vein sinuses, vitelline venous sinuses as well as septum transversum.

Editor's Note: After emailing the doctor about this confusion regarding the embryonic development of the liver tissue, he replied by: "All originated from the mesenchyme of septum (including Kupffer cells and connective tissue) except the hepatocytes endodermal in origin". Without any further explanation.

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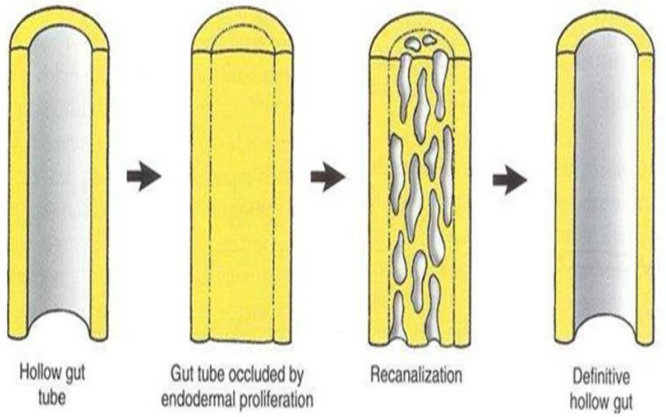
(5:20–>6:45)

Kuppfer cells = macrophages cells of the liver

9 -Gallbladder Development

Solid stage



Extra figure

- **Bile duct development:**
- ✓ While hepatic cells continue to penetrate the septum, the connection between the hepatic diverticulum and the foregut (duodenum) narrows, forming the bile duct .
- ✓ The liver is a **mixed** gland, its **exocrine** part includes the **bile duct.**
- ✓ The **first** to develop is the **common bile duct**, which initially forms as a **solid column of proliferating** cells and later goes through **canalization**.
- ✓ As it **extends** into the developing **liver tissue**, it **gives rise to the hepatic ducts..**
- From the **right hepatic duct**: cell proliferation forms the cystic duct.
- At the **end** of the **cystic duct:** the wall of the **gallbladder** begins to develop.

10-Liver and Gallbladder Abnormalities

- ✓ Liver and gallbladder, like any other organ, can exhibit congenital **abnormalities**, including:
  1) **Accessory** hepatic duct. (Usually asymptomatic)
  2) **Duplication** of the gallbladder **(B)**.(Usually asymptomatic)
  3) **Extrahepatic** biliary **atresia** (blind end --> closed biliary duct lumen --> we have to open it to enable the bile to reach its destination). (Happens because of failure of duct recanalization after its solid stage)
  4) **Intrahepatic** biliary duct **atresia** (requires treatment).

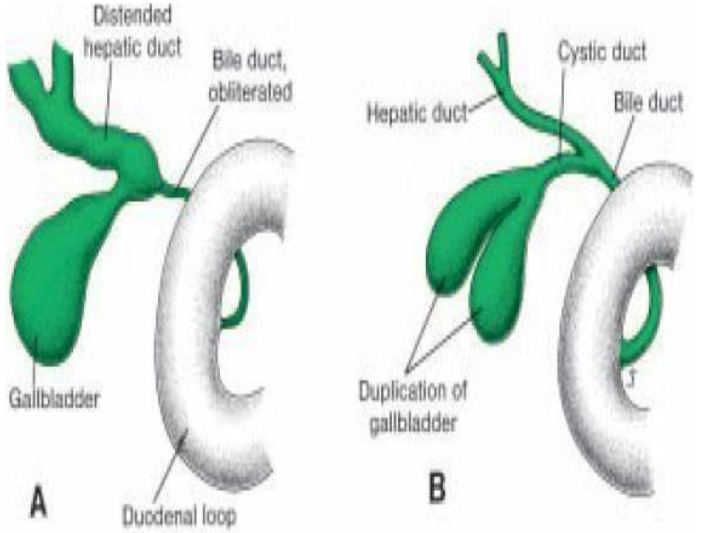
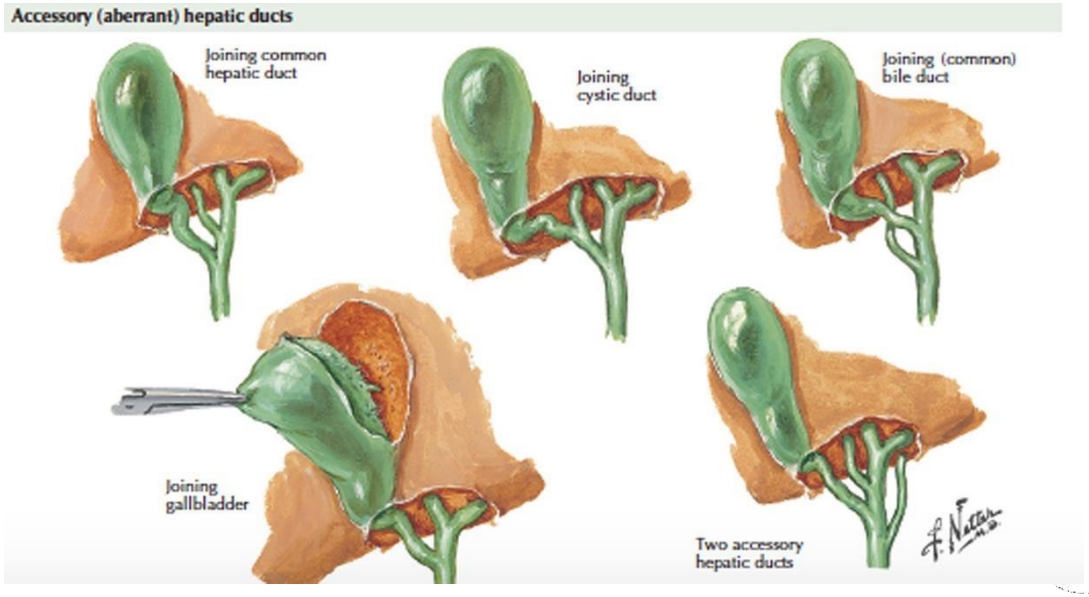


Figure 13.20 A. Obliteration of the bile duct resulting in distention of the gallbladder and hepatic ducts distal to the obliteration. **B.** Duplication of the gallbladder.

- ✓ **Treatment**: If there are **no complications** associated with the abnormality, the patient **doesn't require any intervention**, and the condition is left as it is. However, if complications present, like stenosis of the duct (which results in a decrease in the amount of bile "bile insufficiency"), here intervention must be done to treat the underlying problem.

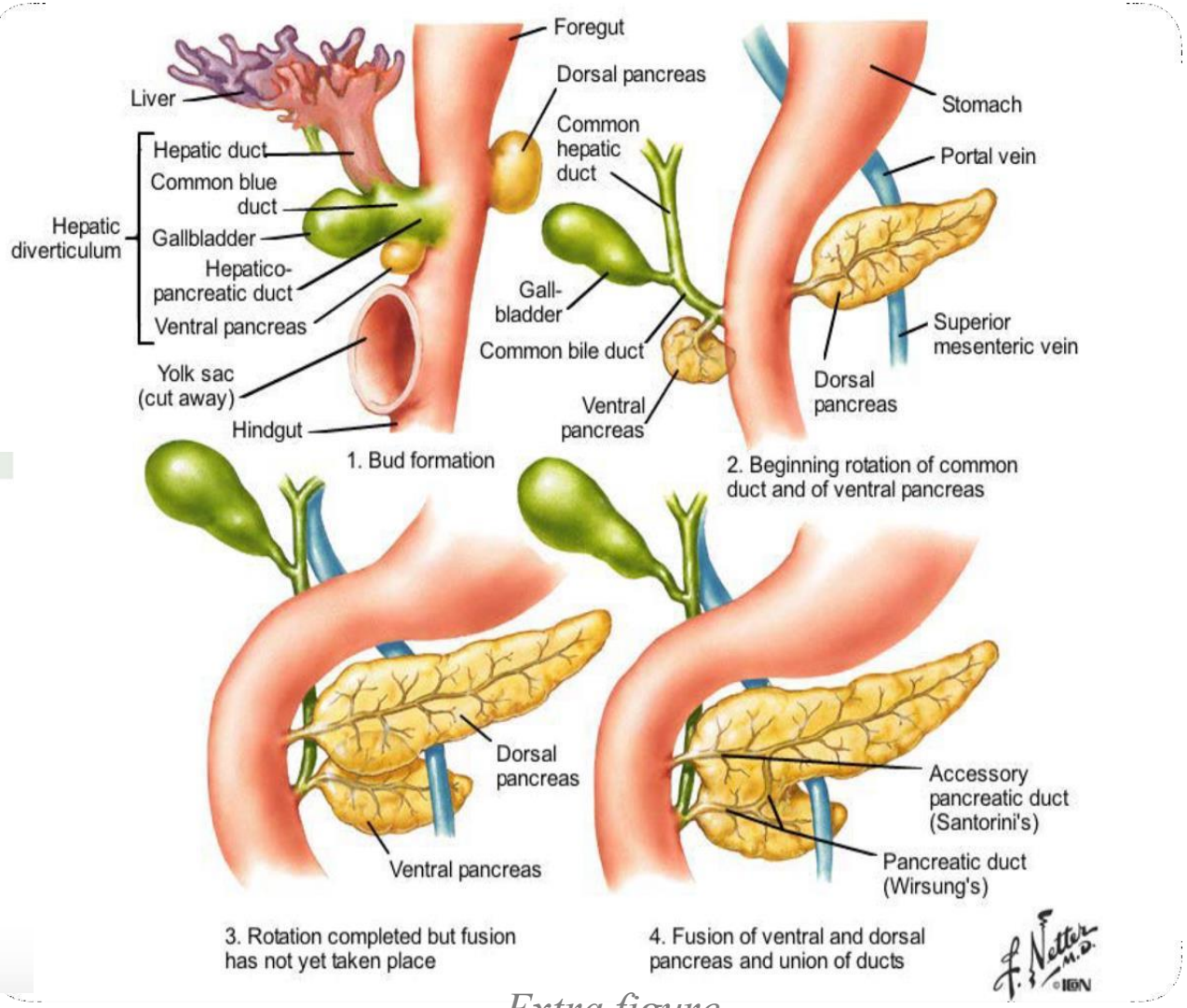
10-Liver and Gallbladder Abnormalities

- ✓ Notice in the image how the rotation facilitates the common bile duct to reach its anatomical position (posteromedial to the second part of the duodenum). It rotates behind the duodenum deep to the pancreas, then it opens.



Enjoy the illustration of the accessory hepatic duct

Extra figure



Extra figure

11-Duodenum Development

- ✓ The duodenum lies distal to the stomach . Initially, the stomach is fusiform in shape, while the **duodenum** is an **elongated duct (finger-like shape)**. As the **stomach rotates** to the **right** in a clockwise direction , the **duodenum rotates** along with it correspondingly to the **right** . the **dorsal mesogastrium pulls** the **duodenum backwards** and to the **left**, resulting in the **concavity** (its C- shaped loop) of the **duodenum facing left.**
- ✓ During this rotation, the **common bile duct**, which **originally** lies to the **right** of the duodenum, also **shifts** and comes to lie on the **left side of the duodenum** .

- ✓ The duodenum is divided at the major duodenal papilla into an upper half derived from the foregut and a lower half derived from the midgut (different blood supply)
- ✓ The terminal part of the foregut and cephalic part of midgut located on the junction of the duodenum, the junction is two parts directed distally to the origin of the liver bud

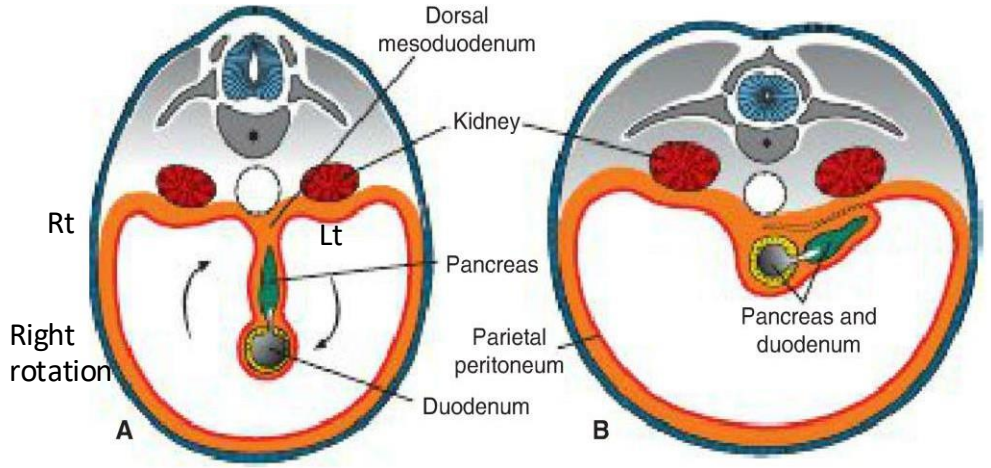


FIGURE 15.17 Transverse sections through the region of the duodenum at various stages of development. At first, the duodenum and head of the pancreas are located in the median plane **(A)**, but later they swing to the right and become attached to the posterior abdominal wall **(B)**.

11-Duodenum Development

- ✓ The **dorsal mesogastrium** that moves the duodenum is composed of **two layers** : anterior and posterior .
- ✓ The **posterior** layer **disappears**, while the **anterior** layer **covers** the anterior surface of the **duodenum** and the **pancreas**, thus making the duodenum and pancreas **retroperitoneal organs.** They rest on the **posterior abdominal wall** with **no peritoneum** behind them.
- ✓ However, the **first** and **last inches** of the duodenum remain **intraperitoneal**. The first inch, located immediately after the **pylorus**, is called the **'duodenal cap'** and is completely covered by peritoneum.

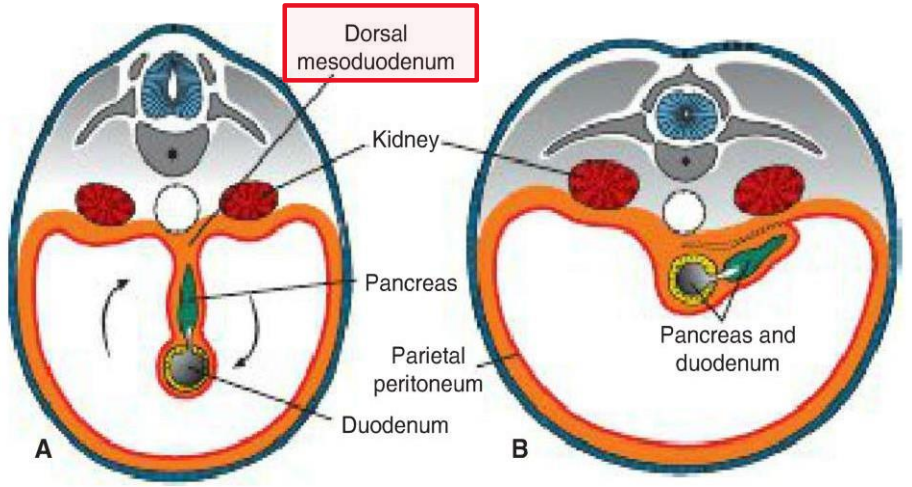


FIGURE 15.17 Transverse sections through the region of the duodenum at various stages of development. At first, the duodenum and head of the pancreas are located in the median plane **(A)**, but later, they swing to the right and become attached to the posterior abdominal wall **(B)**.

12-Duodenal Abnormalities

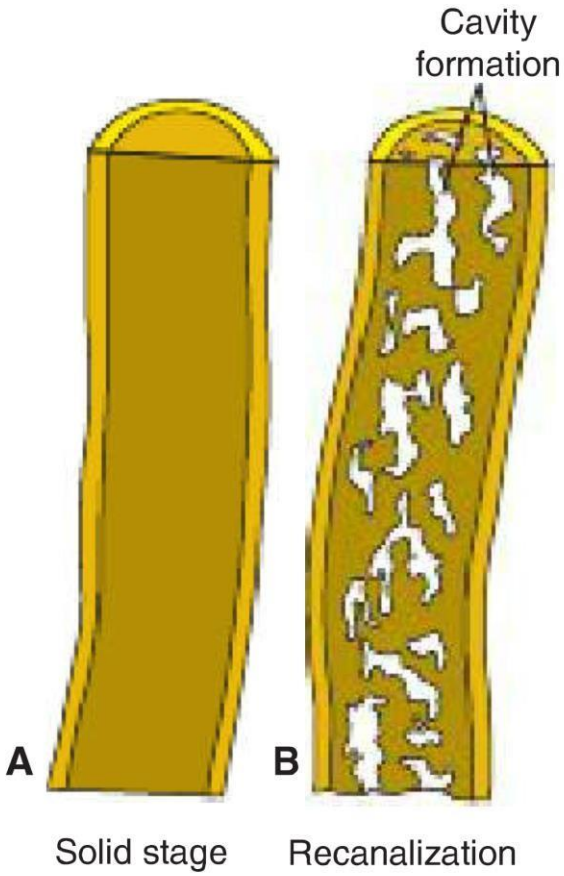


FIGURE 15.18 Upper portion of the duodenum showing the solid stage **(A)** and cavity formation **(B)** produced by recanalization.

- ✓ In a similar fashion of biliary duct development, the development of the duodenum starts with the **proliferation of cells**, leading to **temporary** complete **closure** of its lumen. Then, the proliferated cells are absorbed, leading to the **recanalization** of the duodenum and the formation of a **clear lumen**.

- ✓ One of the **abnormalities** in the duodenum is its **obliteration**, where it becomes filled with proliferated cells (failure of recanalization). This causes an **obstruction**, preventing food from passing through, so **surgical correction** is needed to **reopen** the passage. (Duodenal atresia).

13-Pancreas Development

- ✓ The pancreas develops from **two buds**: **the dorsal** and **the ventral** **pancreatic buds.**
  -The **ventral bud** is **initially** located **below** the **common bile duct** (below the liver bud)(Fig 15.19). As the stomach and duodenum **rotate** clockwise, **the ventral bud** **rotates posteriorly** and **clockwise**, shifting to lie **below** **the dorsal bud** (Fig 15.20).
  - Recall the shifting position of the opening of the **common bile duct** (both **the ventral bud** as well as the bile duct shift in a similar manner).

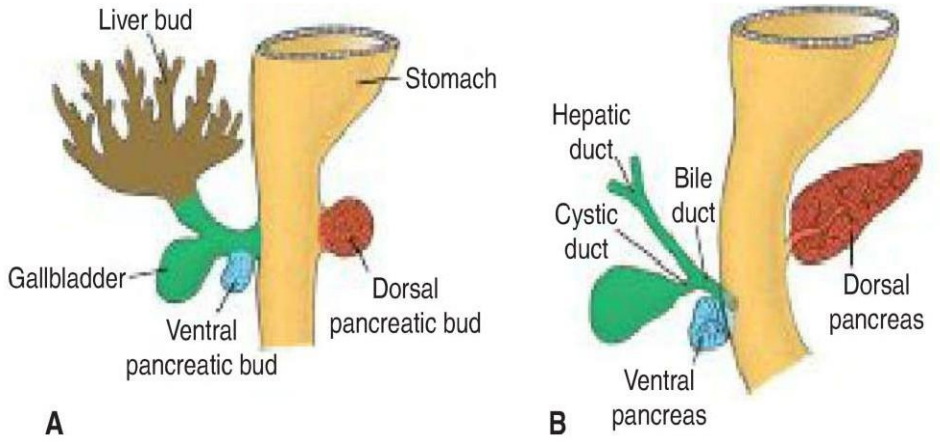


FIGURE 15.19 Stages in development of the pancreas. **A.** 30 days (approximately 5 mm). **B.** 35 days (approximately 7 mm). Initially, the ventral pancreatic bud lies close to the liver bud, but later, it moves posteriorly around the duodenum toward the dorsal pancreatic bud.

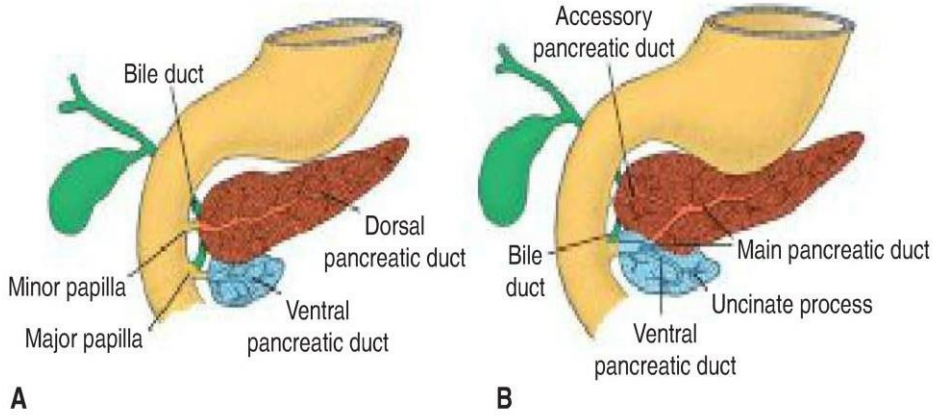


FIGURE 15.20 **A.** Pancreas during the sixth week of development. The ventral pancreatic bud is in close contact with the dorsal pancreatic bud. **B.** Fusion of the pancreatic ducts. The main pancreatic duct enters the duodenum in combination with the bile duct at the major papilla. The accessory pancreatic duct (when present) enters the duodenum at the minor papilla.

13-Pancreas Development

✓ **The ventral bud forms:**

1) The inferior part **(the lower half)** of the **head** of the pancreas.
2) The **uncinate process**.

✓ **The dorsal bud forms**:

1) The remaining part of the pancreas (most of the pancreas is formed by **the dorsal bud**).

✓ Formation of **the pancreatic ducts**:

-The **main pancreatic duct (of Wirsung)** is formed by **the distal part** of the dorsal pancreatic duct and **the entire** ventral pancreatic duct**.**

-The **proximal part** of the dorsal pancreatic duct **either** is **obliterated** or **persists** as a small channel, **the accessory pancreatic duct (of Santorini).**

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(6:45–>7:15)

13-Pancreas Development

- ✓ The **parenchyma** of the pancreas :

  The pancreas is a **mixed** gland; the **endocrine** part is the **pancreatic islets** (**of Langerhans**), which are cells present in the pancreatic tissue and are able to **proliferate**.

- ✓ **Insulin** secretion begins at approximately the **fifth month** (of gestation).
- ✓ **Glucagon-** and **somatostatin-secreting cells** also develop from **parenchymal cells**.
- ✓ **Splanchnic mesoderm** surrounding the pancreatic buds forms the pancreatic **connective tissue**.

14-Pancreatic Abnormalities

- ✓ One of the **abnormalities** of the pancreas is 1)**ectopic pancreas (Accessory pancreatic tissue)**, which refers to the presence of pancreatic tissue in locations other than its normal site.

- ✓ A **more serious** abnormality is 2)**annular pancreas**, in which the ventral pancreatic bud abnormally rotates around the duodenum and obstructs it, leading to **duodenal blockage (complete obstruction)** instead of moving to its normal position below the dorsal bud, in this case, **surgical intervention** must be done.

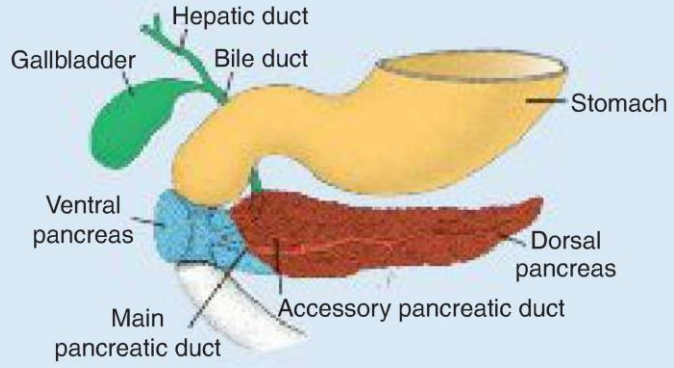
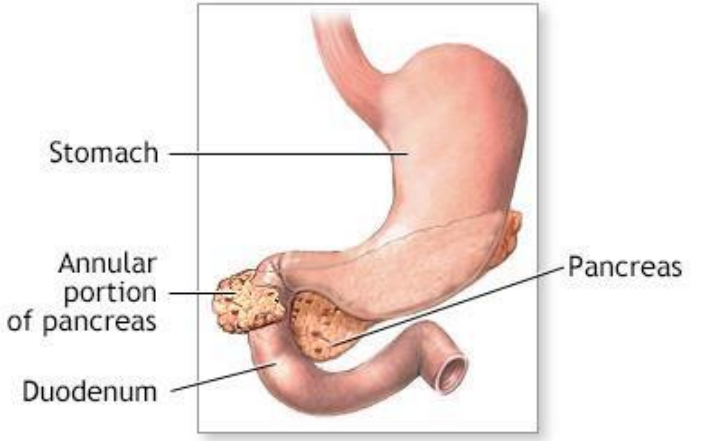


FIGURE 15.23 Annular pancreas. The ventral pancreas splits and forms a ring around the duodenum, occasionally resulting in duodenal stenosis.



Extra figure

A.D.A.M.

رسالة من الفريق العلمي:

" يا أيها الناس!إياكم والغلو في الدين ؛ فإنه أهلك من كان قبلكم الغلو في الدين ".
(رواه ابن ماجة وصححه الألباني).

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			