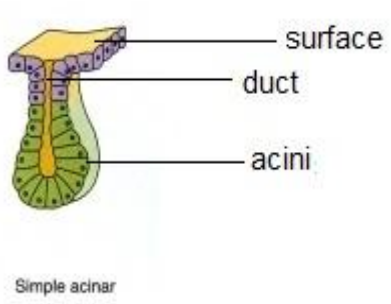
Embryology- GIT- Lecture #1

Today we're going to talk about the embryology of the GIT

Glands in General:

- In general glands develop by *starting* from the **surface epithelium** *through* the **connective tissue**. So the first step is proliferation of epithelial cells (division and penetration through the mesenchymal layer (connective tissue layer)).

If the gland was an **exocrine gland** this means it has **a duct**; **canalization** of the cells (a canal in between the cells), while the **end** of the cells turn into **acini**, where they secrete into the lumen, and the duct opens onto the surface.

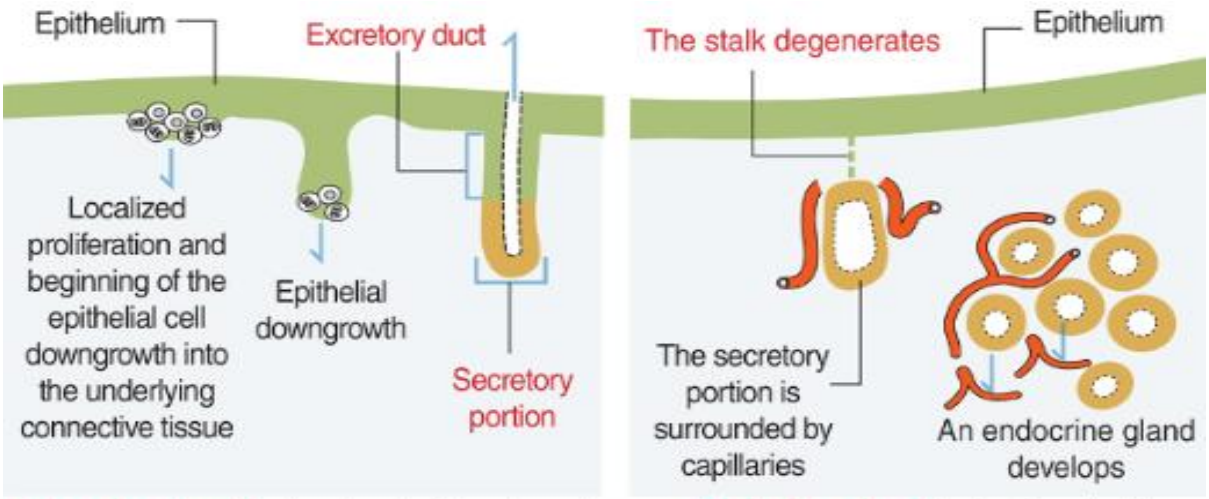


Simple acinar

While in **endocrine glands** the **duct disappears**, and this is the difference between exocrine and endocrine glands (**exocrine glands have ducts while endocrine glands are ductless**).

In **endocrine glands** the duct turns into **follicular cells** (e.g.: thyroid gland) or into **a cord like structure** (e.g.: suprarenal gland). Because it's ductless the secretion is directed toward the middle or to the cells that's why it's rich in blood supply (**the secretion moves directly towards the blood unlike exocrine glands where the secretion is directed towards the duct**)

(Look at the following picture, it's very helpful)



Exocrine gland: A gland product is released onto the **surface**.

Endocrine gland: A gland product is released into the **blood**.

1. Development of Salivary Glands:

- Salivary glands are **exocrine** glands
- Salivary glands are the **parotid gland, submandibular gland,** and **the sublingual gland**.
- In the **7th week** of development, they arise **as solid outgrowth cells** from the wall of the developing mouth (so it starts from the mouth in the oral cavity) and outgrows into the underlying connective tissue forming epithelial buds.
- The epithelial buds are solid and undergo **canalization to form the ducts** which open onto the surface, and in the opposite side (the ends of the ducts) the acini are formed.
- As we know, salivary glands are surrounded by a capsule, this **capsule** is formed from the **surrounding connective tissue** (the surrounding mesenchyme surrounds the gland and forms a septa that forms lobes and lobules in the gland).

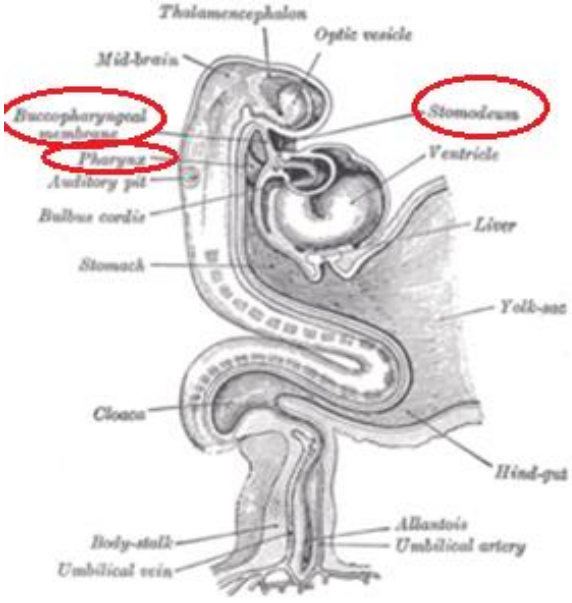
connective tissue=mesenchyme

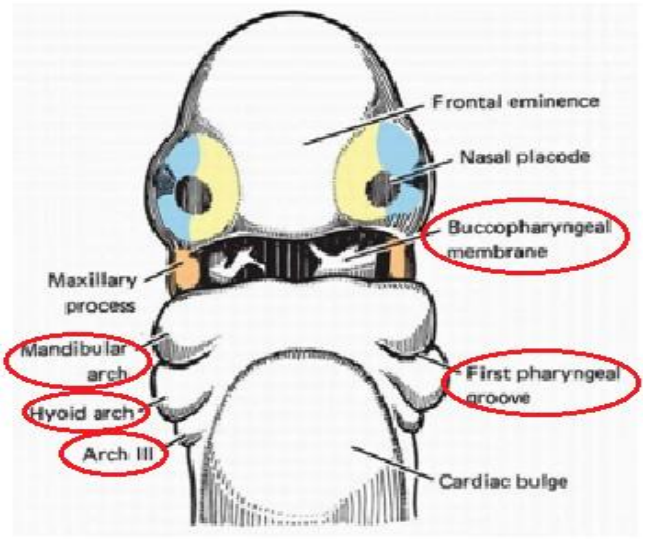
- The **parotid gland and its duct** are **ectodermal** in their origin.
- The **Submandibular and sublingual glands** are **endodermal** in their origins. (endoderm is also named as entoderm)

2. Development of the Mouth (Oral Cavity)

Now please look at the following figures and notice the following:

1) Baccopharyngeal membrane 2)Pharynx 3)Pharyngeal arches 4)Stomodeum





-The **buccopharyngeal membrane** separates the oral cavity from the foregut, especially the pharynx.

- The development of the mouth begins from a depression on the stomodeum; which is a part of the mouth.

So the mouth develops from two sources:

1. A depression on the **stomodeum** (lined with **ectoderm**)
2. Cephalic end of the **foregut** (lined with **endoderm**) (it's the highest part of the foregut)

so these two points are separated by the buccopharyngeal membrane.

- During the 3rd week of development the buccopharyngeal membrane **disappears**.
- The mentioned membrane does disappear, but in order to describe the development of the oral cavity, we're going to imagine an imaginary line that extends from the body of sphenoid (the highest area in the pharynx) to the soft palate (the roof of the oropharyngeal isthmus) to the inner surface of the mandible (inferior to the incisor teeth).

Now superior-anterior to this line are the following structures:

- Hard palate
- Sides of the mouth
- Lips
- Enamel of the teeth

} All are **ectodermal** in their origin (**epithelium**)

Posterior to the line are the following structures:

- Tongue
- Soft palate
- Palatoglossus and palatopharyngeal folds
- Floor of the mouth

} All are **endodermal** in their origin

3. <u>Development of the Tongue:</u>

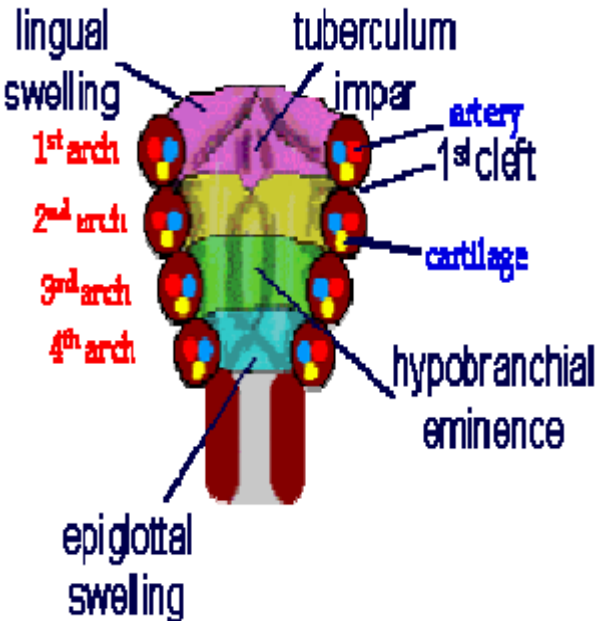
Always, to understand the development, it's better to imagine the final picture of the structure or organ and link it to the stages of development.

- The tongue is divided into anterior two thirds (from the **1st pharyngeal arch**), and posterior third (from the **3rd laryngeal arch**), in between is **the sulcus terminalis** and **foramen cecum**.

Please refer to the following figure in order to understand

- The tongue appears in embryos of approximately **4 weeks** in the form of **two lateral lingual swellings** in the upper most part of the foregut and one medial swelling; **the tuberculum impar**. These three swellings originate from the **1st pharyngeal arch.**

- In the **middle** you can see the tuberculum impar which can be seen in **the floor of the pharynx** (the upper most part of the foregut). It's from an ectodermal origin and it's a swelling coming from the 1st pharyngeal acrh.



In the pharynx there are 6 arches, each arch is from the:

1. Inside is considered **endoderm**
2. In the middle it's considered **mesoderm**
3. From the outside it's considered **ectoderm**

And each one of them will give a different structure or organ.

- **The tongue is endoderm**, the anterior 2/3 arising from the inside of the 1st pharyngeal arch it's endoderm in its origin.

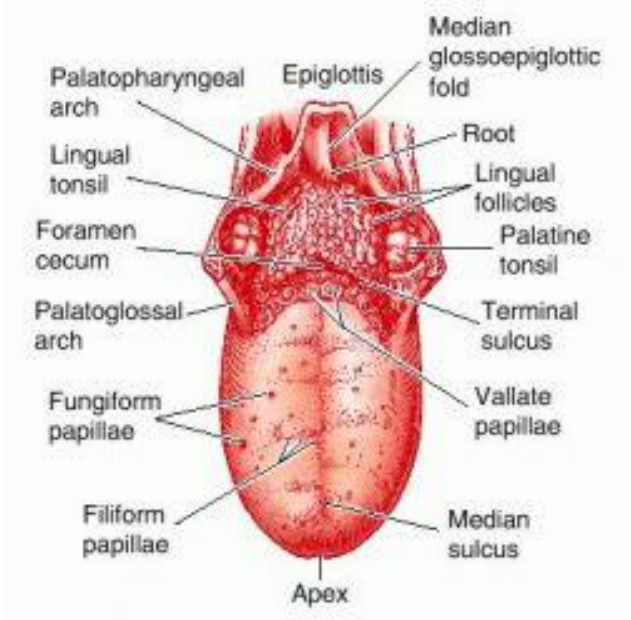
- So in the 1st pharyngeal arch, in the beginning we have the **tuberculum impar**(median swelling), then you have the **2 lateral lingual swellings** that grow towards the midline, then these 3 parts (tuberculum impar & the 2 lateral linual swellings) **fuse together** forming the **anterior 2/3** of the tongue.

- The thyroid gland descends to its place while it's attached to the **foramen cecum** by a duct.
- The innervations of the **1st arch** is from **the trigeminal nerve**, and the **anterior 2/3** of the tongue which arise from the 1st arch is innervated by the **lingual nerve** which is a branch of the mandibular division of the trigeminal nerve.

- The **posterior 1/3** of the tongue is innervated by **the glossopharyngeal nerve**. (Indicates that it originates from a different arch than the anterior 2/3 of the tongue).

- In the posterior 3rd there's what's named by **copula**, **or hypobranchial eminence**, it **enlarges** in the floor of the pharynx, after that it **disappears** and it's replaced by a swelling from the **3rd pharyngeal arch**.
- So the 3rd pharyngeal arch undergoes development and extension to the **midline** forming the **posterior 1/3** of the tongue which is innervated by **the glossopharyngeal nerve**.

- **Sulcus terminalis** is the space in between the **1st and 3rd** pharyngeal arches, and it reaches the **foramen cecum.**



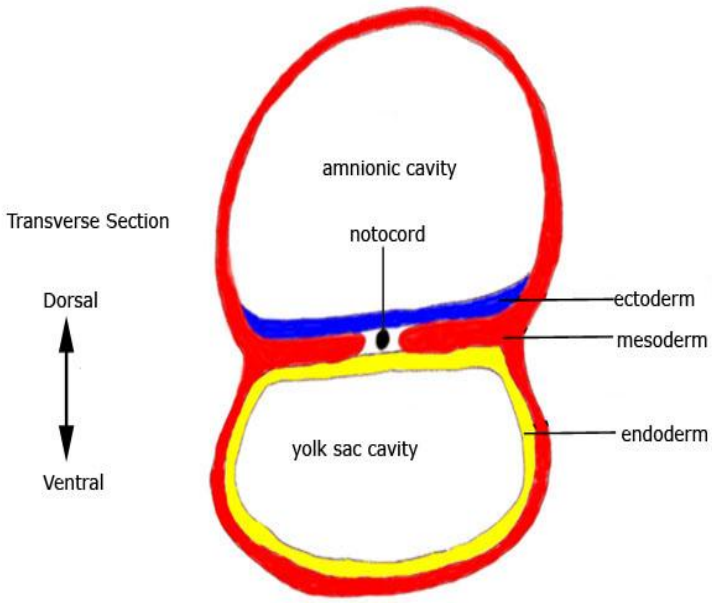
4. Development of the Pharynx:

- **The floor** of the pharynx is the **most superior part of the foregut.**
- The pharynx develops in the neck from **the endoderm** of the foregut
- -The endoderm forms the arches, arches form the pharynx.
- -In the middle there's a **mesoderm**.
- The **ectoderm** forms the **clefts** or **grooves**.

So the development of the pharynx is **endodermal from pharyngeal pouches.**

5. The Development of the Anterior Abdominal Wall

- The fertilization of a sperm with a mature ovum in **the fallopian tube** forms a **zygote.**
- The zygote then becomes a **blastocyst**.
- When it's implanted in the posterior wall of the uterus it becomes **a bilayer/bilaminar germinal disc (embryonic disc).**
- These 2 layers are the ectoderm and the endoderm. (in most of the pictures The ectoderm is blue, and the endoderm is green.)
- They start as two layers, and then become **a trilaminar germinal disc** where a layer named the **mesoderm** develops in between the ectoderm and endoderm layers.

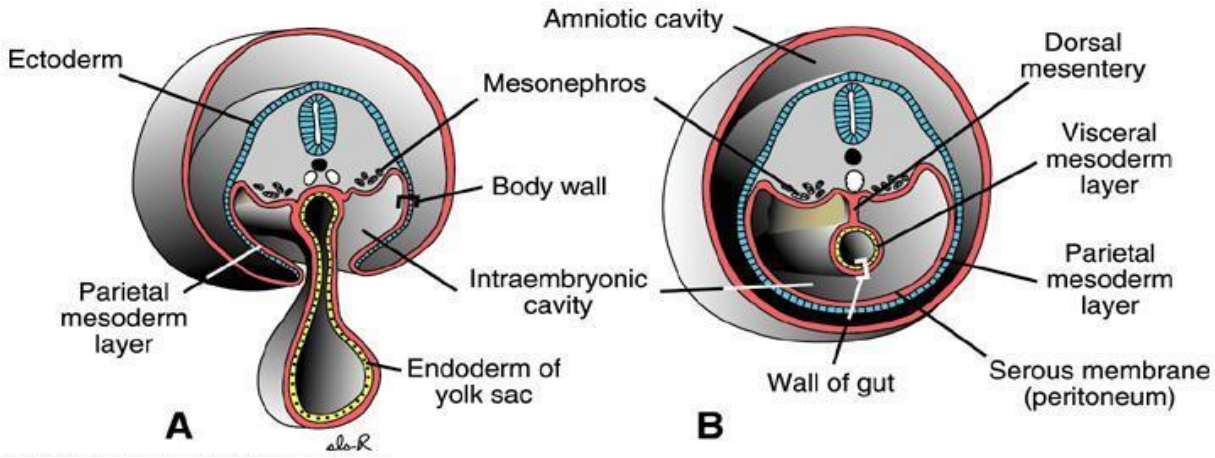


The Mesoderm that's formed is divided into:

1. **Somatic Mesoderm**: firmly attached to the anterior abdominal wall. (جداري)

2. **Splanchnic Mesoderm**: around the viscera (Visceral).

The somatic mesoderm forms the **parietal peritoneum**, and the splanchnic mesoderm forms the **visceral peritoneum**.



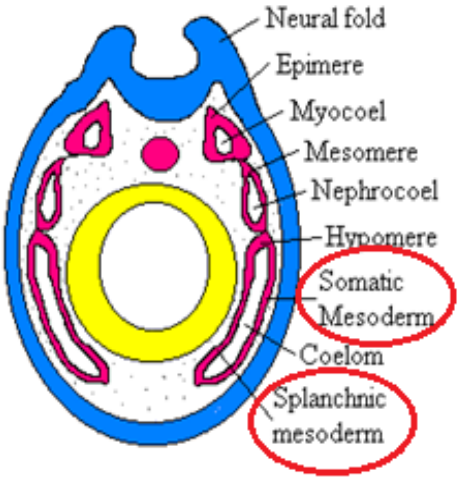
6. Development of the Mesodermal Layers:

1- The mesoderm in the beginning is formed of two **open** layers, and there's an **Extra-embryonic coelom** (that opens outside the embryo).

2- During the development this coelom begins to enlarge at the expense of **the yolk sac** (which is a space in the endoderm).

3- The gut is formed (later forms the GIT) covered by **splanchnic** mesoderm/mesenchyme which is **the visceral peritoneum**.

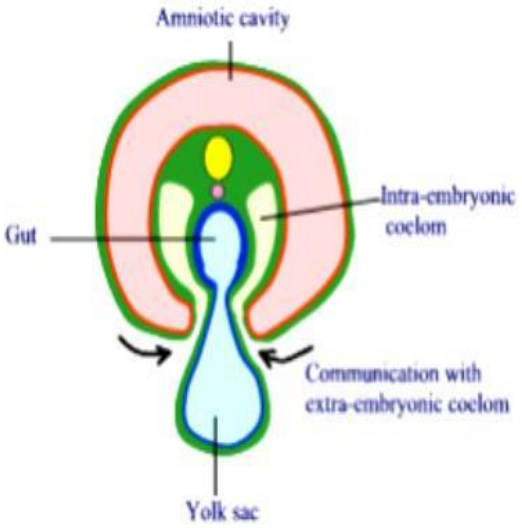
4- Attached to the **ectoderm** (the body wall) on the outside there's **skin** and on the inside is the **somatic** mesoderm/ mesenchyme which is the **parietal peritoneum**.



7. Development of the abdominal cavity:

The abdominal cavity is the space formed between the mesodermal layers known as the closed **Intra-embryonic coelum** or the **chorionic cavity**. (check the picture to the right)

The ectoderm forms the skin.



The **somatic** or **somatopleuric mesoderm** forms the abdominal wall, which has **segmental innervation** (an example of segmental innervation is the lower 6 intercostal nerves that innervate the skin around the xiphoid by T7, around the umbilicus by T10 and above the symphysis pubis by L1).

8. Development of the abdominal muscles:

The **somatic mesoderm** splits giving us: External oblique, Internal oblique and Transversus abdominis muscles; therefore the 3 muscles are **mesodermal** in origin. These muscles undergo expansion to the midline forming **Linea Alba**.

As for **Rectus abdominis** it comes between the apponeurosis of these 3 muscles that form the **rectus sheath**. Rectus abdominis originates from **somatic myotomes** (قطع جنينية) that are originally from the mesoderm.

These myotomes adhere to the **anterior wall** of rectus sheath and remain there even after birth until the rest of the person's life.

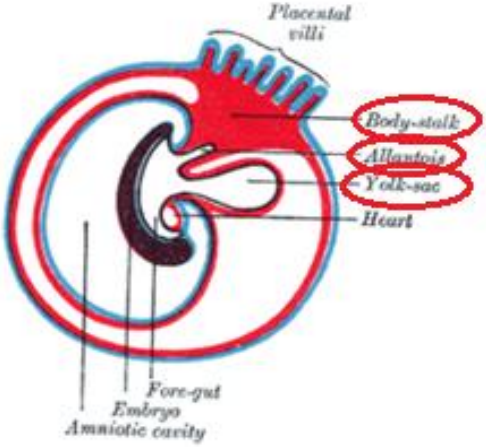
In the midterm a question about the tendinous intersections being adherent to the posterior wall of the rectus sheath, this is exactly why it is false.

9. Development of the Umbilicus and the Umbilical Cord:

During embryogenesis the embryo undergoes folding, after this folding, we have the head cephalically, caudally the tail and the GIT is prominent in the middle showing the foregut, midgut, hindgut.

The **midgut** is connected to the umbilical cord through the **vitelline duct** in the yolk sac. As for the **hindgut** it is connected to the umbilical cord through the **allantois**. (Check the picture to the right)

Before folding we have a body stalk that contains the umbilical cord and other structures (check the following picture).



After the folding the placenta is formed and the **umbilical cord** is prominent, containing:

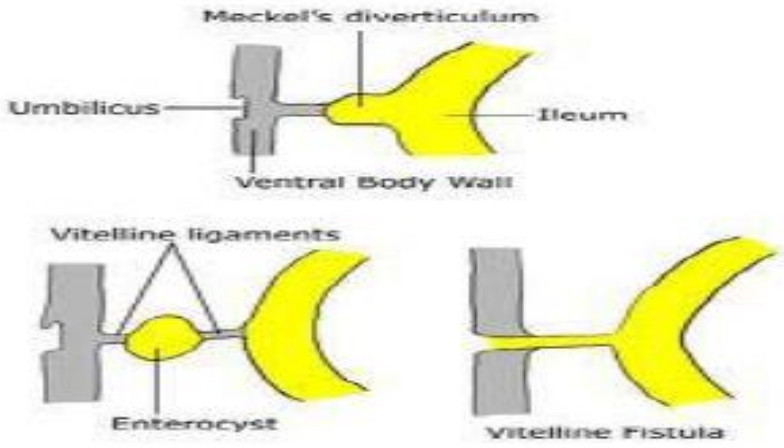
- The Vitelline duct. (from the **midgut**)
- Umbilical blood vessels.
- Remains of the allantois. (to the **hindgut**)
- Remains of the yolk sac.
- The umbilical cord is formed of mesenchymal tissue (Wharton's jelly).

*Recently there has been an increased interest in preserving and freezing umbilical cords, as they have a lot of stem cells that can be useful in the future for treating diseases of the person. *

The umbilical blood vessels: are 2 arteries and 2 veins, during development the right vein disappears. **Arteries** carry **deoxygenated** blood to the placenta (choroin). **Veins** carry **oxygenated** blood to the fetus.

Abnormalities in the Vitelline duct: the vitelline duct is present between the **umbilicus** and the **midgut**, normally it should be obliterated. If it wasn't obliterated, abnormalities occur:

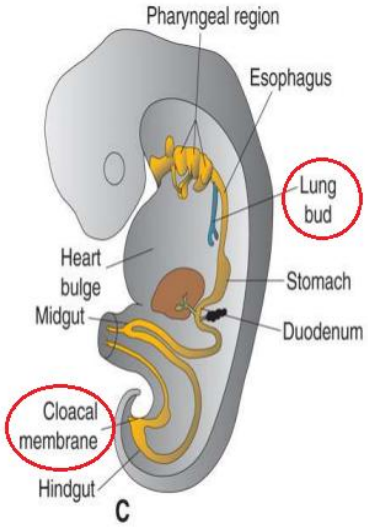
1-**Fibrous band** (usually associated with Meckel's diverticulum)
2- **Vitelline cyst**: both ends of the vitelline duct transform into fibrous cords, and the middle portion forms a large cyst. Does not have complications.
3- **Fecal Fistula**: if the vitelline duct remains open, so feces from the ileum protrude from the umbilicus.
4-**Meckel's Diverticulum**: a small pouch in the ileum by the remaining vitelline duct.



Meckel's Diverticulum: Present in **2%** of people, it is **2 inches** in length, **2 ft.** from the iliocecal junction. Contains gastric or pancreatic tissue. Does not usually cause any symptoms, but it's associated with some **complications** like: *Past paper question*

-Intestinal obstruction.
-Inflammation.
-Ulceration.
-Bleeding.
-Peritonitis; caused by perforation of Mickel's Diverticulum.

* If **the allantois** remains connected to the umbilicus, a **Urachus** will appear which secretes **urine** not intestinal material if it remained open. It's between the urinary bladder and the umbilicus.*



10. Development of the Gut:

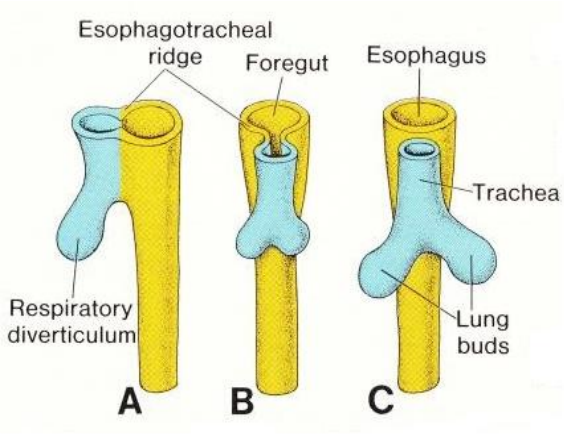
The pharynx is the beginning of the foregut, then we have the esophagus, over it we have a **tracheobronchial diverticulum** which is called **the respiratory bud**, this is where the respiratory tract forms, in front of the esophagus.

Then the GIT continues until the end of the hindgut called **the cloaca** which ends in the **cloacal membrane** that gives rise to: (check the picture on the right)

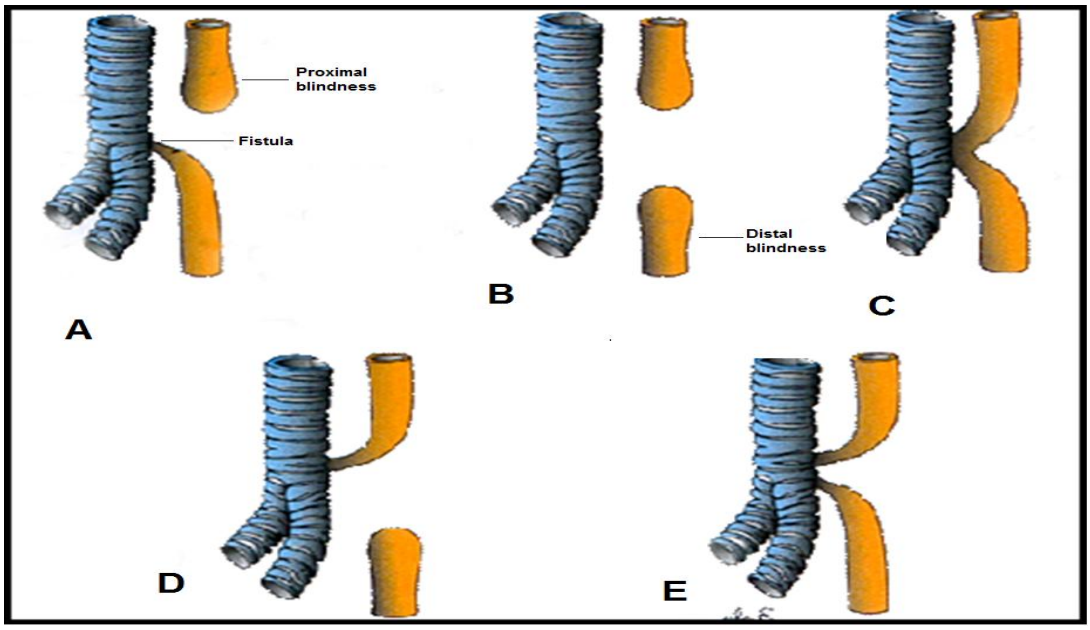
- Anal canal.
- Urinary bladder.

A. Development of the Esophagus:

- Develops from a narrow part of the foregut right below the pharynx. First it starts **high up** but with the enlargement of the heart and diaphragm, it **descends rapidly downwards**.
- Anterior to it is the respiratory bud in early embryonic life, but constriction occurs directly from **the lateral side to the midline**, forming a septum which separates the esophagus from the respiratory tract.



A wide range of **abnormalities** occur in the development of esophagus:



Please refer to the previous picture for the next abnormal cases A,B,D,E

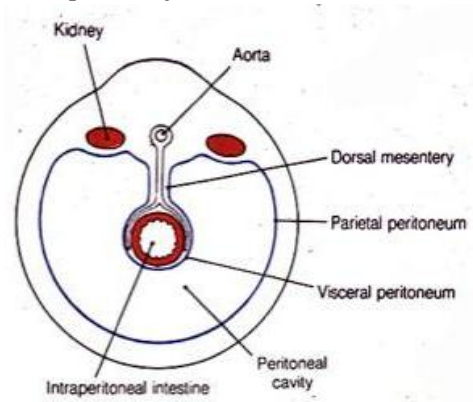
- **A → Proximal blind end or Proximal Esophageal Atresia with a fistula in the distal part of the esophagus connects it to the trachea.**
  Esophagus is closed; child can't drink milk and will keep vomiting.
  Esophageal Atresia with / without tracheoesophadeal fistula Occurs in 1:3000 births.
- **B → Two blind ends in the proximal and distal esophagus.**
- **D → Distal blindness and a fistula in the proximal part.**
- **E → Two fistulas** (H shaped)

- <u>Esophageal abnormalities are often associated with other types of abnormalities:</u>

- **33% with a cardiac abnormality:** inter-atrial septal defect or inter-ventircular septal defect.
- Anal canal abnormalities (imperforated or absent).
- Kidney abnormalities.
- Lower limb abnormalities.
- **Polyhydramnios**: increase in the amniotic fluid due to obstruction. Amniotic fluid normally goes to the respiratory tract and GIT where it is absorbed to keep its amount constant , but when obstructed it goes back to the amniotic cavity. (Opposite to it is oligohydramnios where there is decrease in the fluid)
- Pneumonia (due to the connection between GIT and RT, some particles may go to the lungs.)
- Air from the respiratory tract will cause distention in the stomach, so when the baby cries the abdomen will bulge.

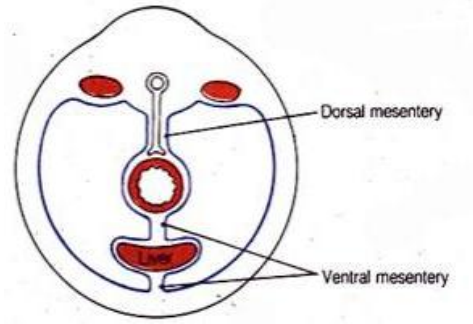
They all need urgent treatment, to separate the esophagus from the respiratory tract.

B. <u>Development of peritoneum and peritoneal cavity:</u>



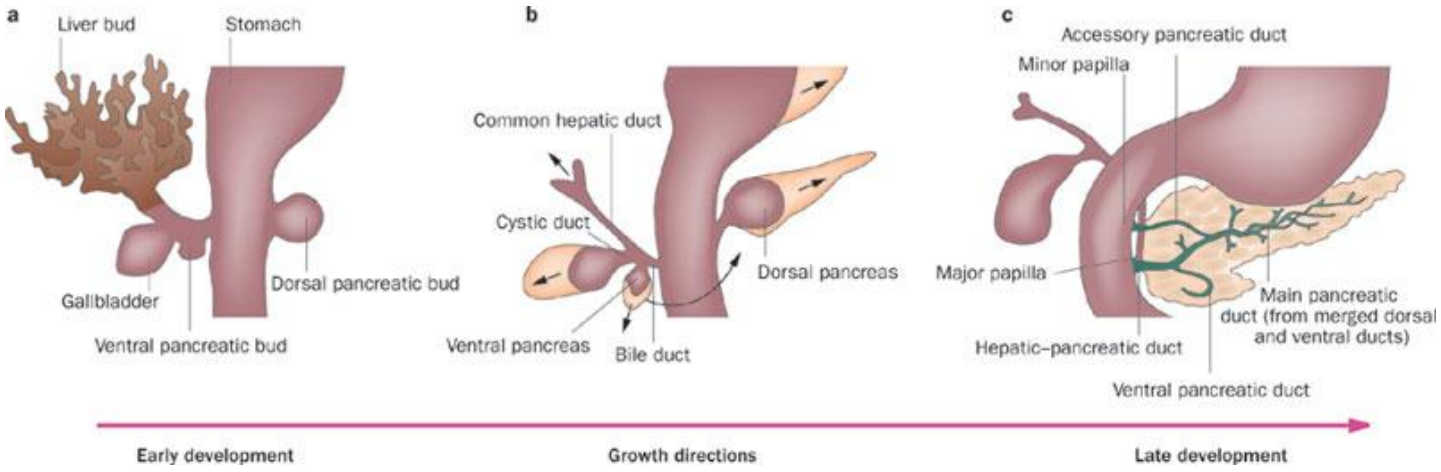
- Remember: The ***Somatic Mesoderm*** forms the *Parietal Peritoneum* and the ***Splanchnic Mesoderm*** forms the *Visceral Peritoneum*
- The ***Ventral and Dorsal Mesenteries*** develop to form the *Ligaments and Omenta of peritoneum*

The Foregut ends at the middle of the duodenum; this is marked by the <u>Hepatic Bud</u> in embryology, which forms the liver eventually. Below the hepatic bud directly lies the <u>Ventral Pancreatic Bud</u>. The gallbladder also forms from the hepatic bud. The *Ventral Mesentery* accompanies them.



The *Dorsal Mesentery* is found posteriorly along with the <u>Dorsal Pancreatic Bud</u> (both a ventral and a dorsal bud form the pancreas).

Endodermal cells begin to proliferate from the bud and through the mesenchymal cells (Connective Tissue), forming either endocrine or exocrine glands in the pancreas.
The same thing happened in case of duodenum that develops with the stomach.



C. Development of The Stomach

- Initially: The stomach lies at the midline and it has two openings. It appears as a <u>fusiform</u> dilatation of the foregut (has the shape of an American football).

(In order to clearly picture the embryogenesis of the stomach you must keep in mind its gross anatomy; it has two orifices, two surfaces, and two curvatures.)

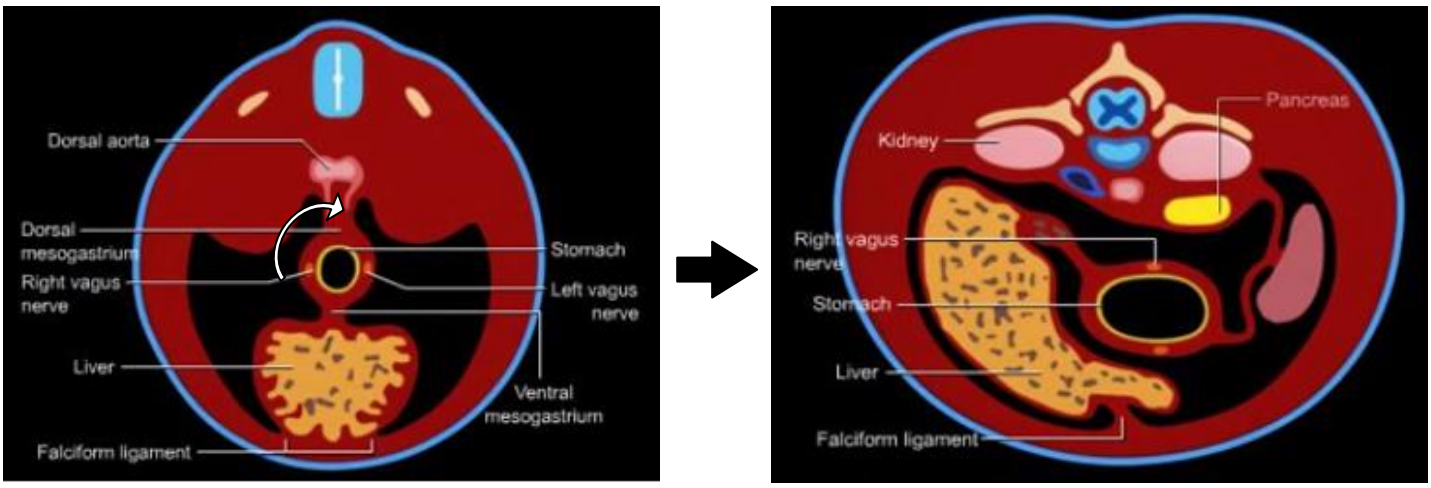
- The stomach rotates in **two directions**, this is due to the enlargement of the mesentery and adjacent organs (such as the <u>liver</u>, enlarges towards the right side and so rotation of the stomach is also to the right –clockwise–), as well as growth of the stomach walls:

A. 90◦ Clockwise around its longitudinal axis:

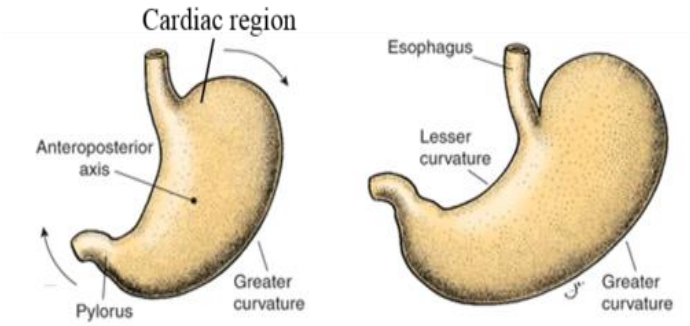
This causes its *left* side to face *anteriorly* and its *right* side to face *posteriorly*, hence the *left Vagus* Nerve which was intitally at the left side of the stomach becomes becomes *anterior*, and the *right Vagus* Nerve becomes posterior.

The ventral mesentry develops and rotates less rapidly than the dorsal mesentery; therefore the *ventral mesentery forms the lesser curvature* while the *dorsal mesentery is larger and forms the greater curvature.*

This rotation leads to the formation of the anterior and posterior surfaces of the stomach.



B. Anteroposterior Rotation



The pyloric and cardiac orifices are initially at the midline, after this rotation:

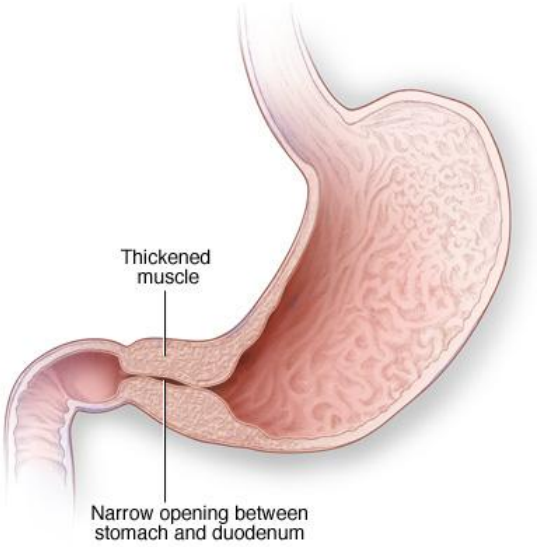
- The *Pyloric Orifice* moves upward and to the right
- The *Cardiac Orifice* moves downward and to the left

Eventually, the *pyloric orifice* will lie at a distance of 1 inch to the right of the midline at the level of L1 while the *cardiac orifice* will lie at a distance of 1 inch to the left at the level of T10.

Those changes lead to the eventual shape of stomach. The pancreas and the duodenum rotate along with it.

- **Clinical Note: Pyloric Stenosis (narrowing)**

- Congenital hypertrophy of the pyloric sphincter; Infants with this anomaly have marked muscular thickening of the pylorus of the stomach.
- Occurs in infants: 3-6 weeks.
- Landmark: **Projectile Vomiting** → the stomach becomes markedly distended and its contents are expelled with considerable force.
- A kid with repeated projectile vomits means they might have pyloric stenosis.



D. Ligaments and Omenta of The Peritoneum

Mesenteries in The Region of The Stomach

Ventral Mesogastrium

Goes in the direction of the liver and hence forms all of its ligaments:

1) **Falciform ligament**: between the liver and the abdominal wall and diaphragm

2) **Lesser Omentum** with the stomach

3) **Coronary Ligaments** with the diaphragm

4) **Triangular ligaments** on its both sides

The stomach is attached by it to the anterior abdominal wall.

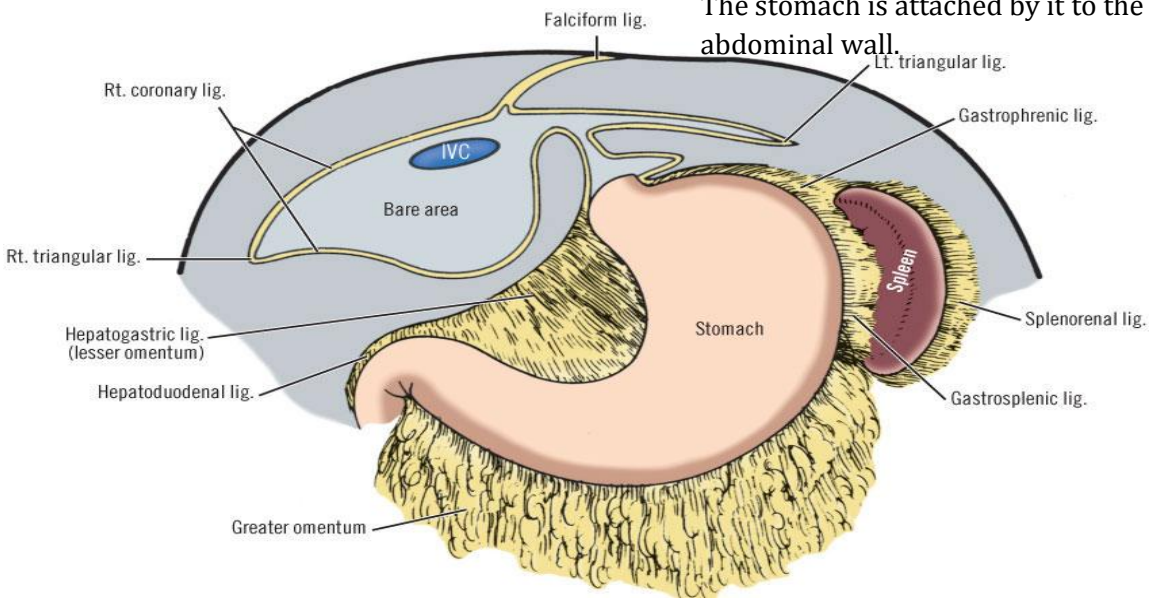
Dorsal Mesogastrium

Forms most of the other ligaments that are not those of the liver:

1) **Gastrosplenic**
connects the stomach to the spleen
2) **Gastrophrenic**;
connects the stomach to the diaphragm
3) **Greater Omentum**: two layers, goes to the transverse colon

4) **Mesentry of Small and Large Intestine** (transverse and sigmoid colons)

The stomach is attached by it to the posterior abdominal wall.



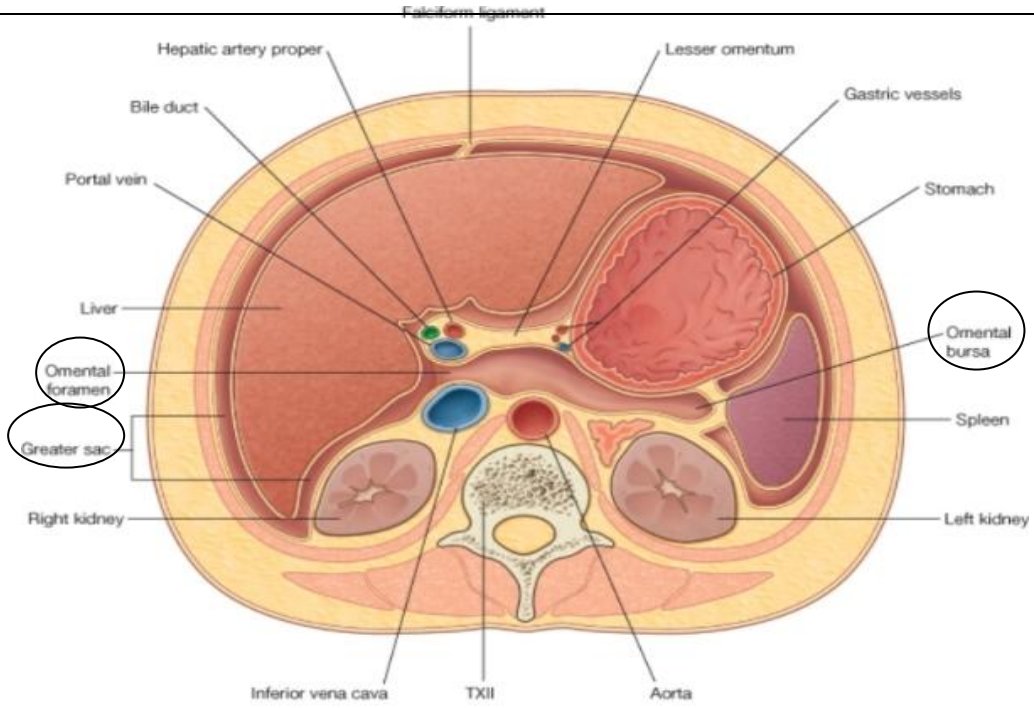
Formation of the Lesser and Greater Omenta:

- The **Lesser Omentum** comes from The Ventral Mesogastrium(mesentery) , lies between the liver and the stomach, and connects the porta hepatis to the lesser curvature of the stomach.

- As a result of rotation of the stomach about its anteroposterior axis, the Dorsal Mesogastrium continues to grow down and forms a double-layered sac extending over the transverse colon and small intestinal loops like an apron, this is the **Greater Omentum.** It develops faster than the Lesser Omentum and covers a wider area. It attaches to the greater curvature and covers the stomach from the fundus to the pyloric sphincter and the first inch of the duodenum.

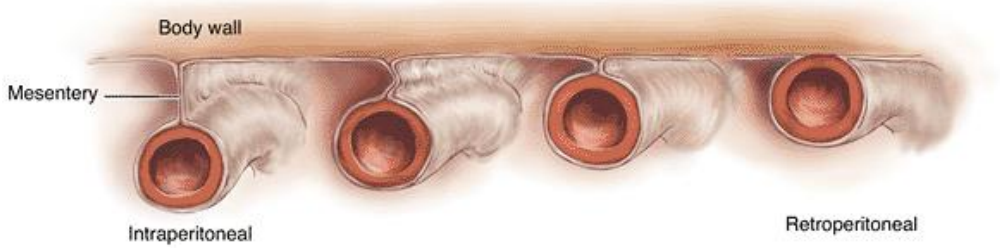
Formation of the Greater and Lesser Sacs:

The rotation and disproportionate growth of the stomach alter the position of the mesenteries. Rotation about the longitudinal axis pulls the dorsal mesogastrium to the left, creating a space behind the stomach called the **Omental Bursa** (lesser peritoneal sac)**.**



❖ Intraperitoneal and Retropeitoneal Organs:

- During the 6th week of development, the capacity of the abdominal cavity becomes greatly reduced due to the enlargement of the liver and the kidney. This alters the relationship of the gut tube to the dorsal mesentery. In some regions, the gut tube is pushed back against the body wall, effectively removing the dorsal mesentery. This condition is called: **retroperitoneal** and the gut tube is essentially fixed. Sometimes, the gut tube pulls farther away from the vertebral column, thus stretching the dorsal mesentery. The gut tube is movable in this case and it appears as though the tube is completely surrounded by the visceral mesoderm. This condition is called: **intraperitoneal**.



- The *dorsal mesentery* (formed by the Splanchnic Mesoderm) forms the *greater omentum*, the two opposing mesoderm layers fuse to form a double-layer membrane, which goes dorsally and then disappears posteriorly. At the site of the pancreas the dorsal mesentery disappears and therefore the pancreas is said to be retroperitoneal. As for the stomach, the mesentery remains and attaches to the posterior abdominal wall as the mesocolon. The mesentery disappears posteriorly for the duodenum and it is hence retroperitoneal (except for the first and last inches).

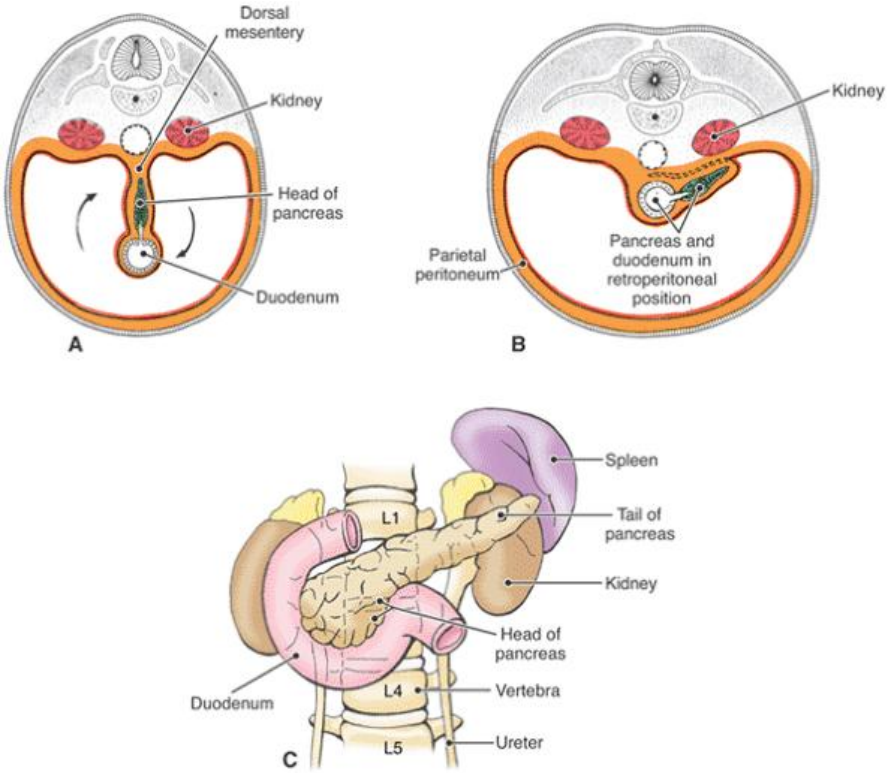
- The **pancreas** initially comes from the pancreatic buds and lies in between the dorsal and ventral mesenteries, but eventually, when it becomes retroperitoneal, any peritoneum that

lies posteriorly disappears, especially that which comes from the mesentery. Only the parietal peritoneum remains behind, such as that of the dorsal abdominal wall.

- **During the rotation of the stomach, the duodenum and the pancreas also rotate and develop:**

The **pancreas** has a ventral pancreatic bud and a dorsal one. The ventral bud will eventually become below the dorsal due to rotation.

The **duodenum** initially was part of the midline. With rotation, it becomes C-shaped with a concavity to the right and backward. The 4 parts form due to the rotation.



- **Clinical Note: Physiological Herniation**

The midgut protrudes into the umbilical cord. This occurs at the 6th week of development due to the decrease in the capacity of the abdominal cavity which causes an increase in pressure.