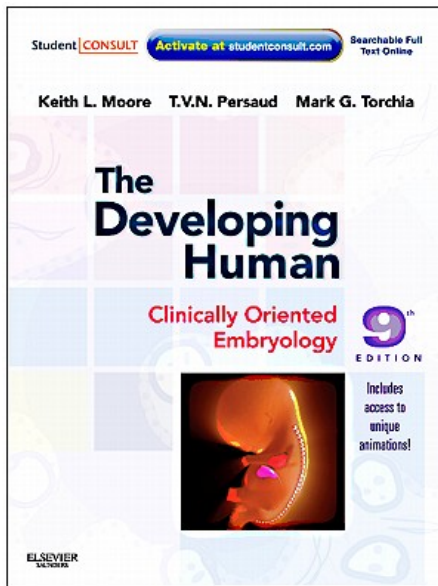


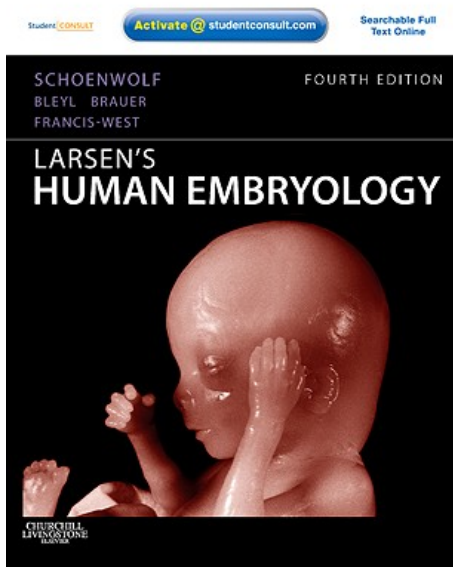
**Endoderm** – *Inner or internal Skin (Gk)*

## Objectives

- Understanding of the derivatives of endoderm
- Understanding of the folding of the embryo and GIT
- Understanding of three main GIT embryonic divisions
- Understanding of germ layer contributions to the early gastrointestinal tract (GIT)
- Understanding of associated organ development (liver, pancreas, spleen)
- Brief understanding of mechanical changes (rotations) during GIT development



**Citation:** The Developing Human: clinically oriented embryology 9<sup>th</sup> ed. Keith L. Moore, T.V.N. Persaud, Mark G. Torchia. Philadelphia, PA: Saunders, 2011.  
[Chapter 11 – Alimentary System](#)



**Citation:** Larsen's human embryology 4th ed. Schoenwolf, Gary C; Larsen, William J, (William James). Philadelphia, PA : Elsevier/Churchill Livingstone, c2009.  
[Chapter 14 - Development of the Gastrointestinal Tract](#)

**Which tissues does endoderm contribute to?**

### Lineage mapping

The lining of the gastrointestinal tract

The pancreas

The liver

The allantois > bladder

The prostate gland

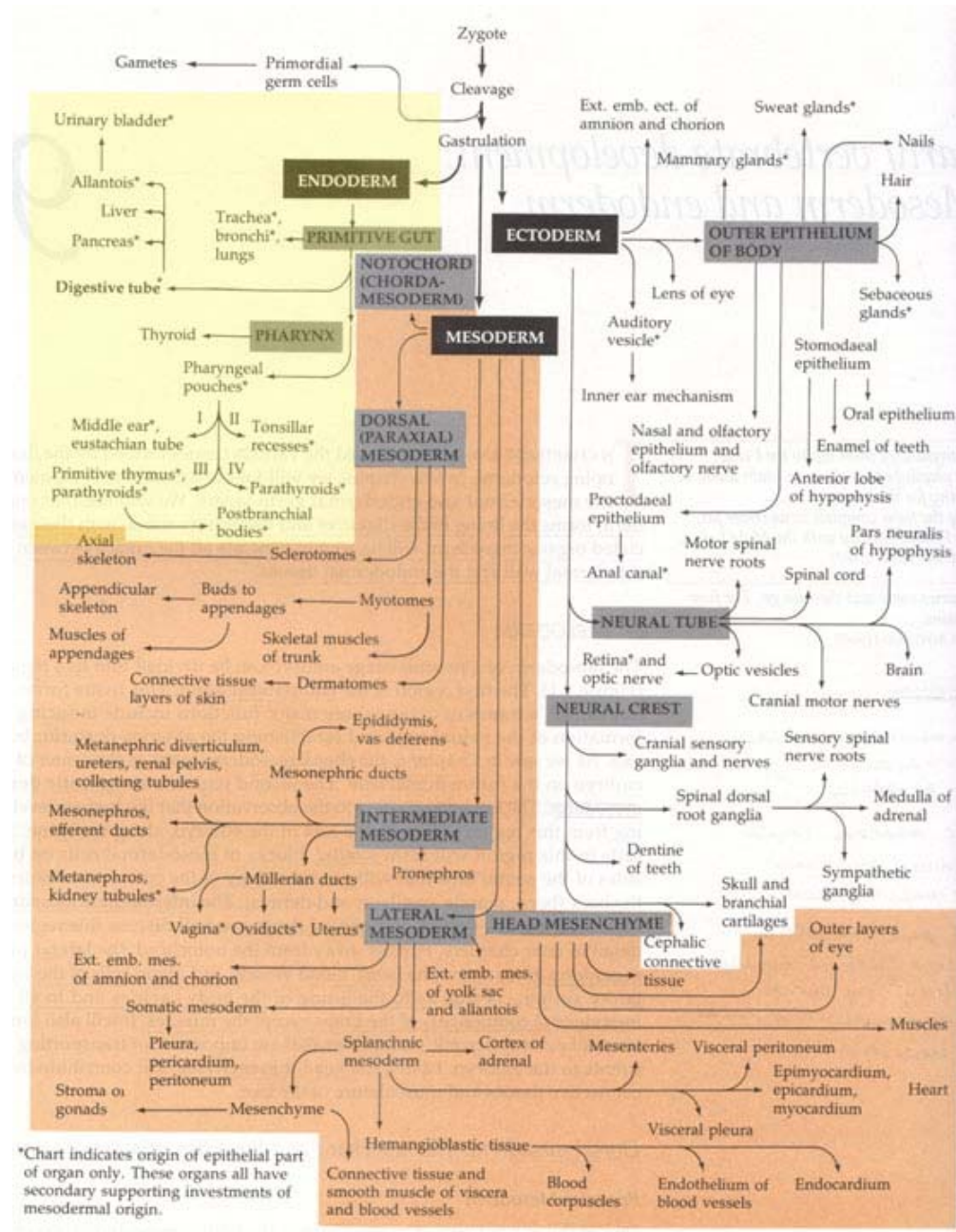
The trachea and bronchi

The lungs

The thyroid gland

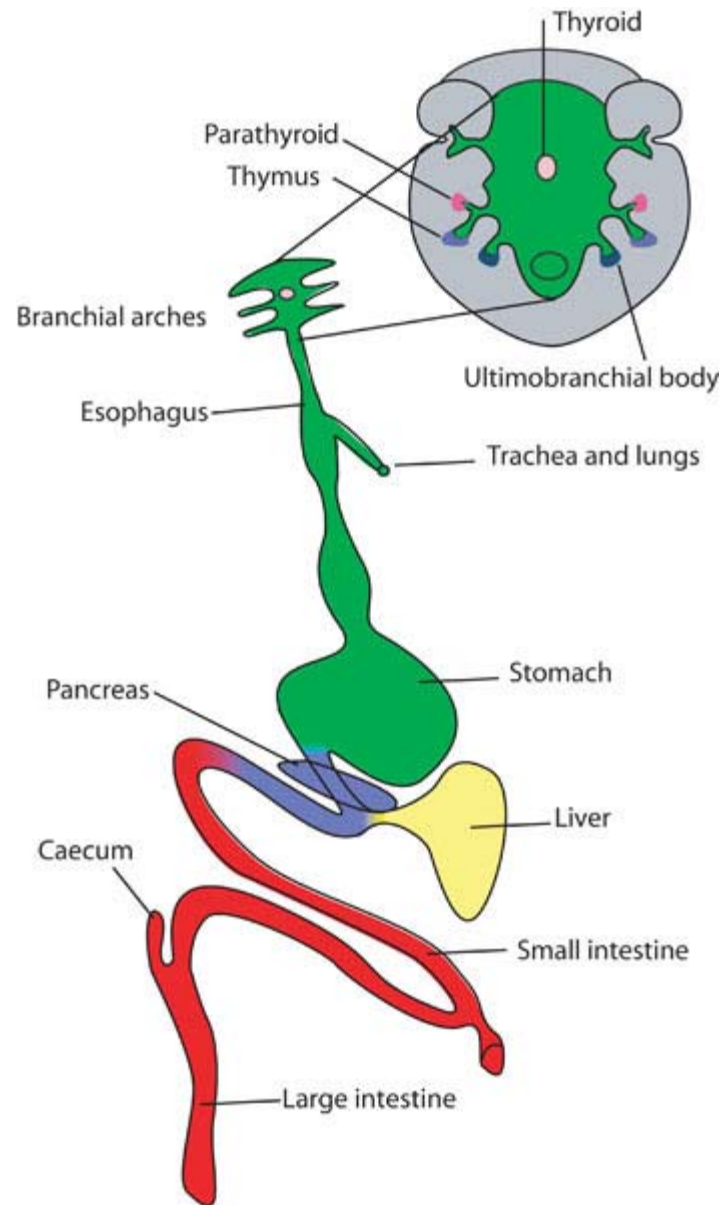
The thymus

Derivatives of the pharyngeal pouches



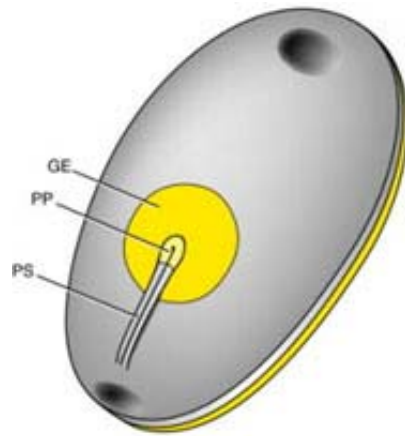
**All endoderm derivatives are formed from outgrowths of an inner tube that mainly constitutes the gut**

The gastrointestinal tract  
The pancreas  
The liver  
The allantois > bladder (not shown)  
The prostate gland (not shown)  
The trachea and bronchi  
The lungs (not shown)  
The thyroid gland  
The thymus  
Other derivatives of the pharyngeal pouches

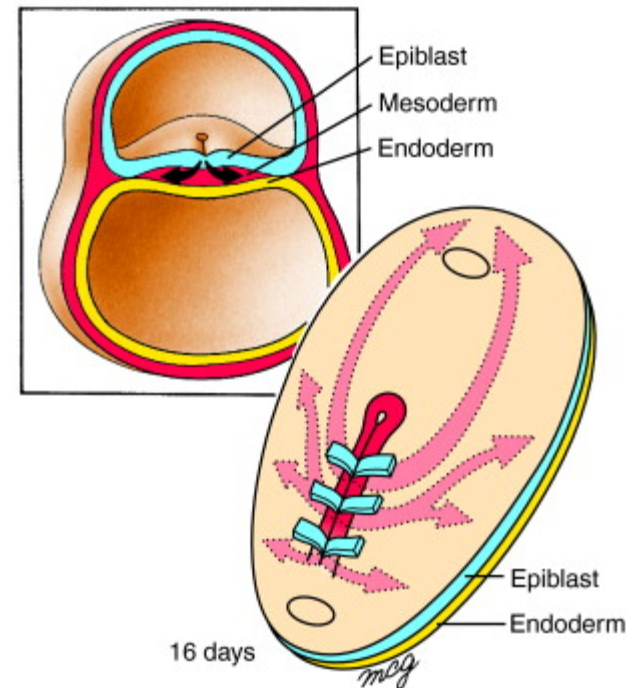


Parafollicular cells of the thyroid - calcitonin

## Where do the endoderm cells come from?

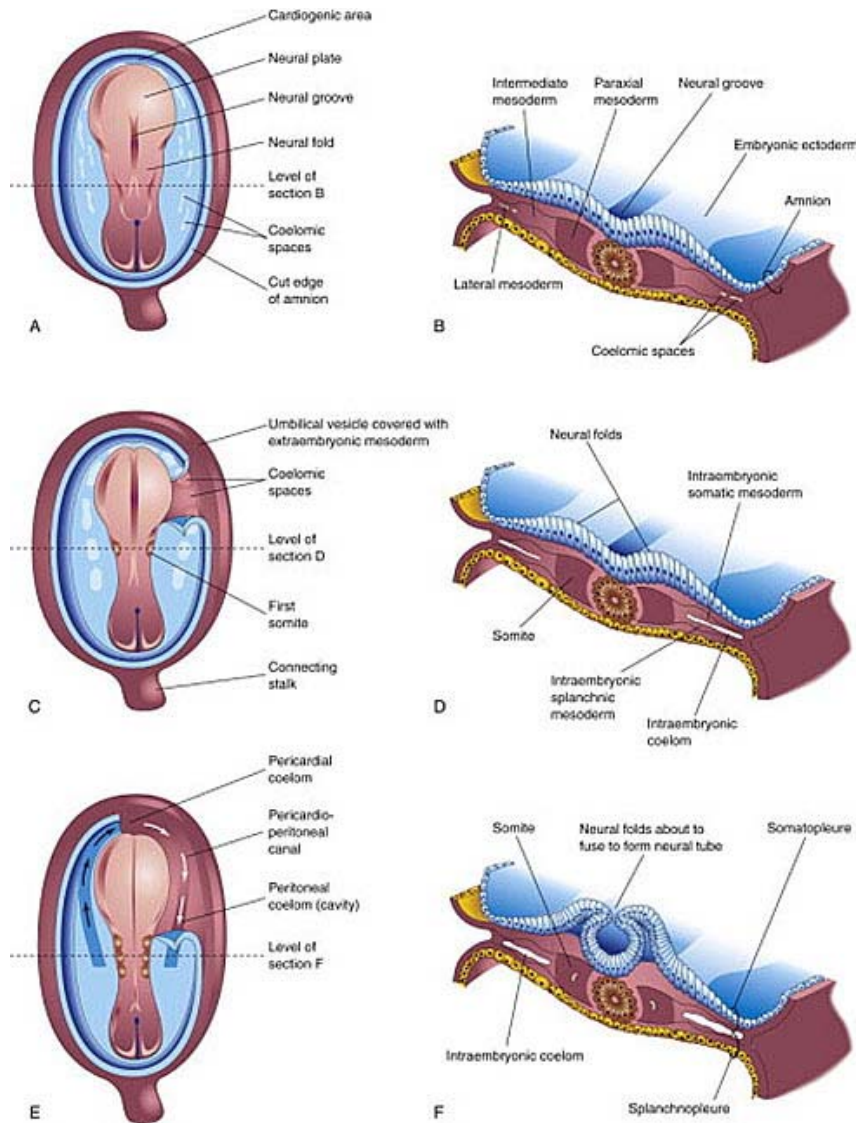


Early primitive streak stage showing locations of prospective gut endoderm (GE) in epiblast and prospective prechordal plate (PP) in the cranial end of the primitive streak (PS; dark outline in subsequent figures). Oval at the cranial end of the epiblast (in all figures) indicates the location of the future oropharyngeal membrane; caudal oval indicates future cloacal membrane.



**Schoenwolf: Larsen's Human Embryology, 4th ed.**  
Copyright © 2008

The lateral plate mesoderm is split into 2 by the formation of the coelomic spaces

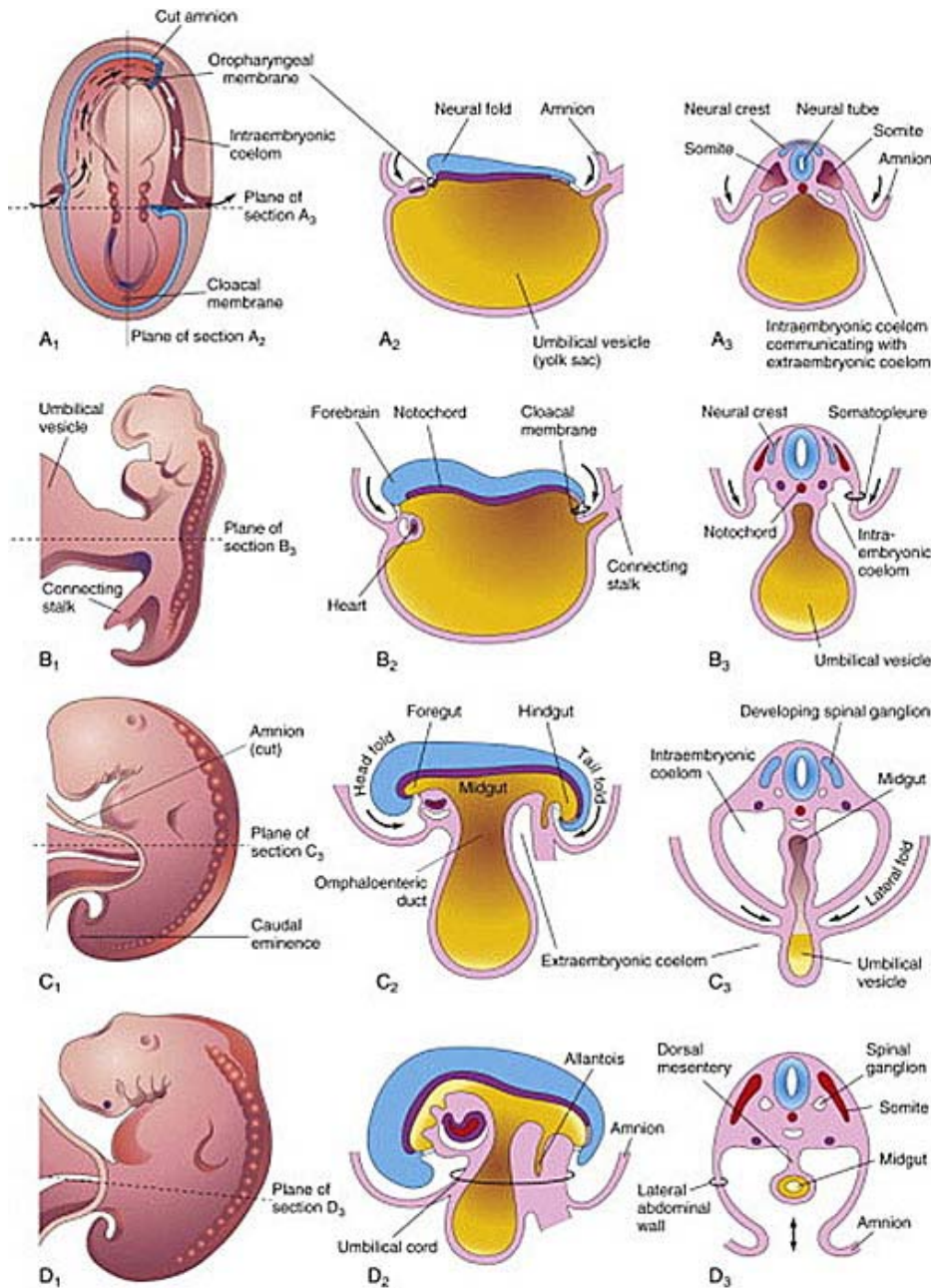


In the lateral plate mesoderm, spaces start to form at several locations which then join to form one continuous cavity called the coelom.

The lateral wall of the coelom then breaks down so that the **intraembryonic coelom** is continuous with the **extraembryonic coelom**

This creates the **splanchnopleure** and the **somatopleure**

From Moore KL, Persaud TVN, Shiota K: *Color Atlas of Clinical Embryology*, 2nd ed. Philadelphia, WB Saunders, 2000.



## Embryonic folding

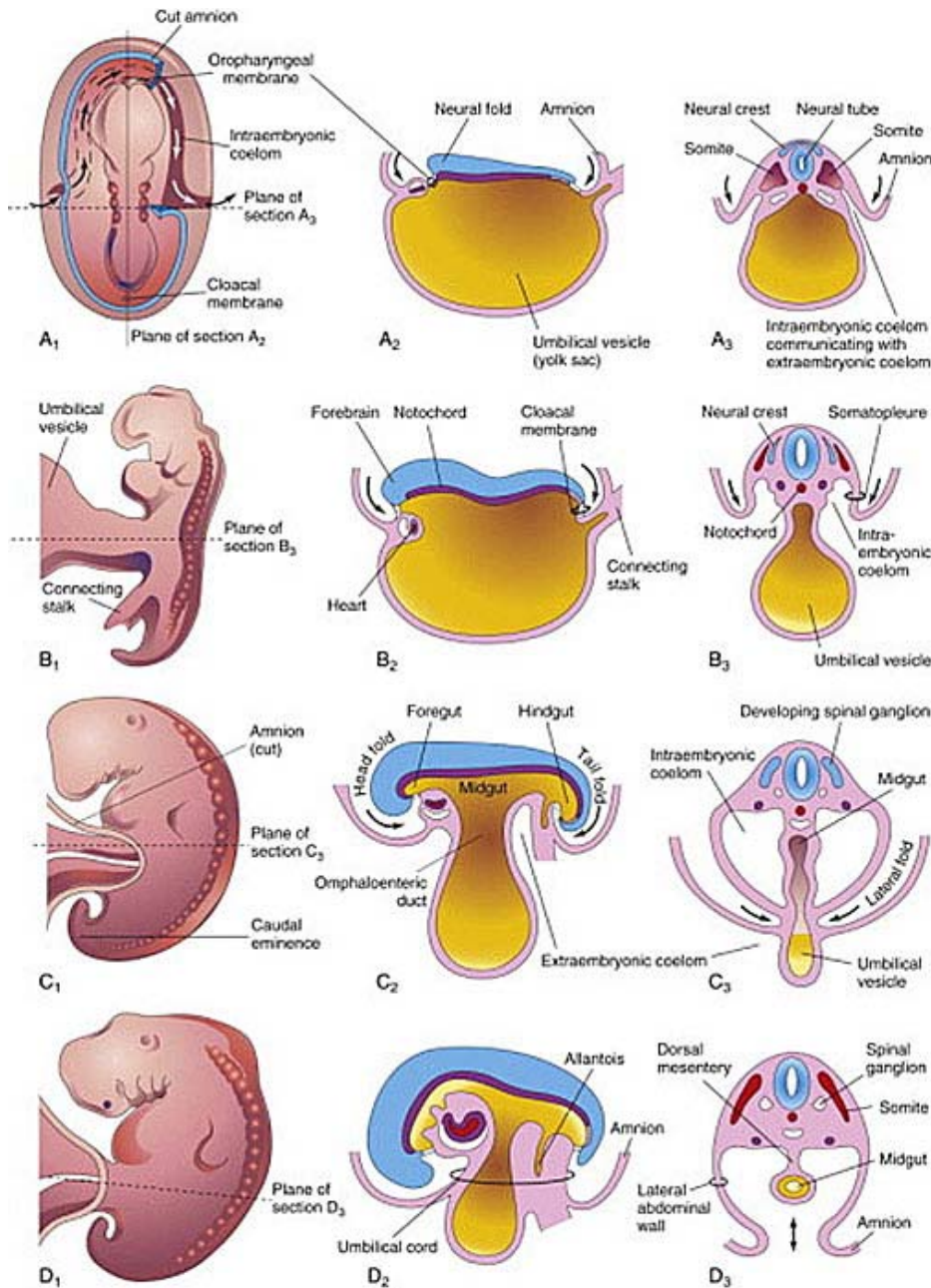
During the 4<sup>th</sup> week, the embryonic disc grows rapidly whereas the yolk sac stagnates

The notochord is a semi-rigid dorsal structure that resists bending

The edges of the embryo fold round under these forces

*From Moore KL, Persaud TVN, Shiota K: Color Atlas of Clinical Embryology, 2nd ed. Philadelphia, WB Saunders, 2000.*





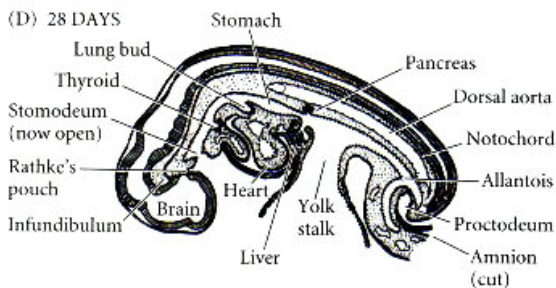
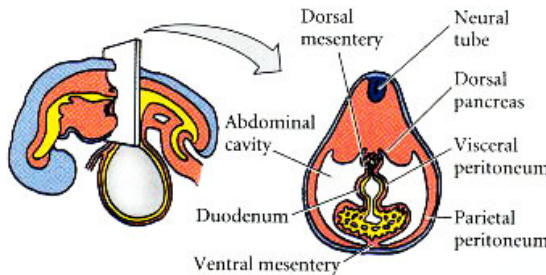
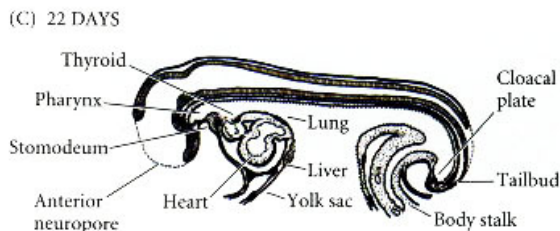
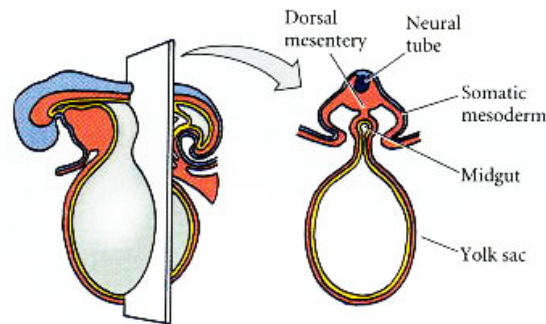
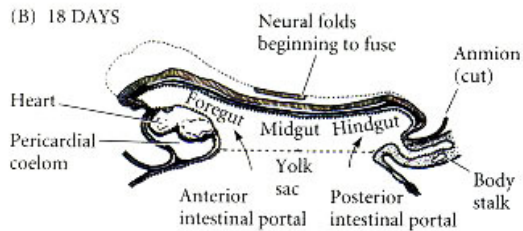
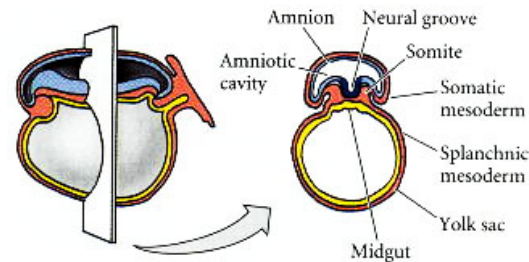
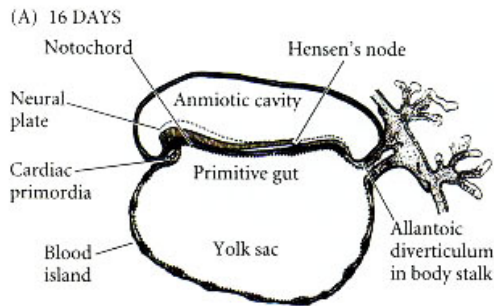
## Embryonic folding

The lower **splanchnopleure** (endoderm+splanchnic mesoderm) folds around to form the gut tube.

The upper **somatopleure** (ectoderm+underlying somatic mesoderm) which is connected to the amnion also folds around the whole embryo.

The membranes fuse with their opposites to enclose the gut and the outer body wall and create the coelomic cavities. The amnion is pulled around the embryo as this process occurs.

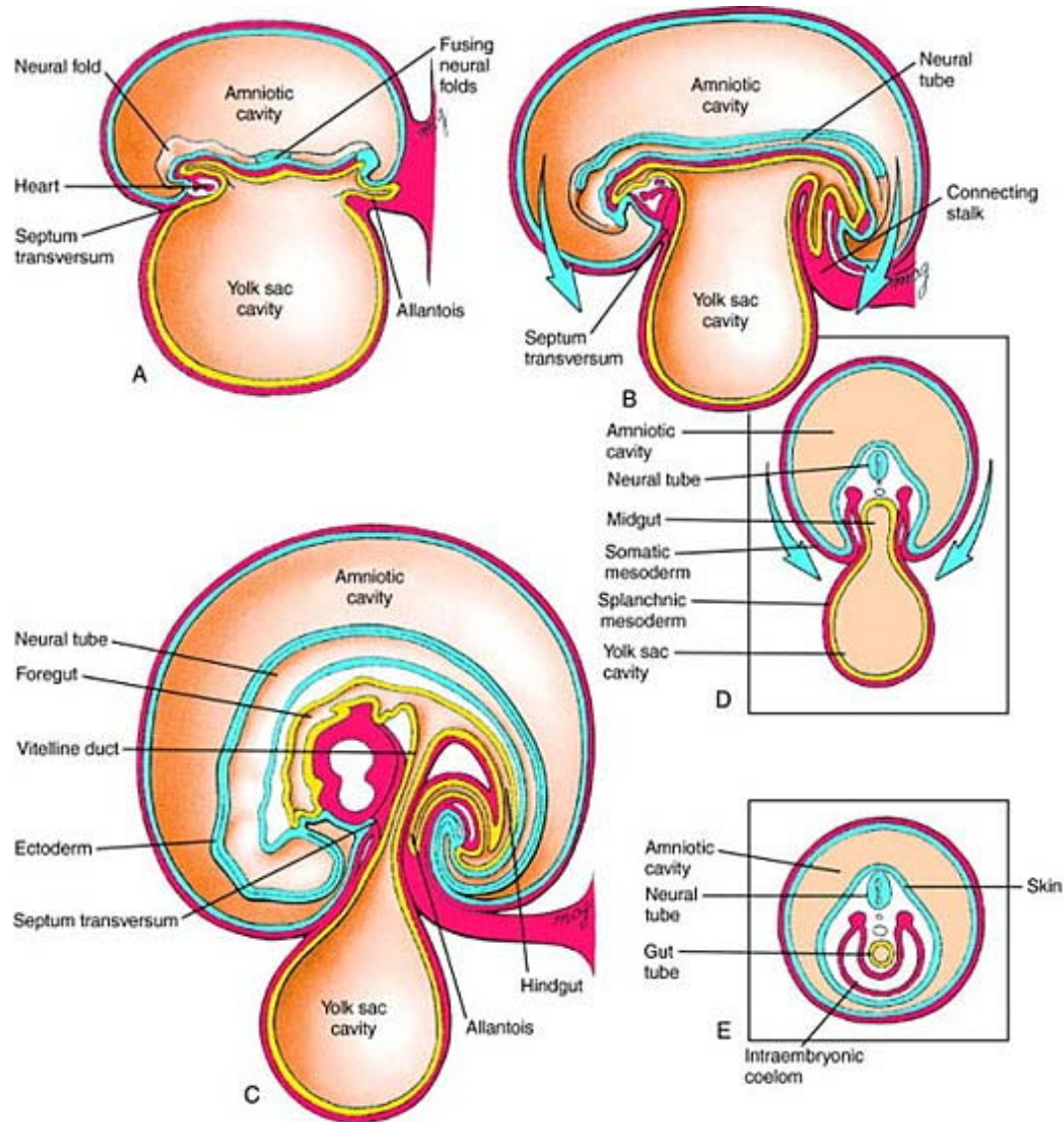
*From Moore KL, Persaud TVN, Shiota K: Color Atlas of Clinical Embryology, 2nd ed. Philadelphia, WB Saunders, 2000.*



## Embryonic folding

The endoderm that starts out as a flat surface is rolled into a tube that finally fuses at the abdominal midline

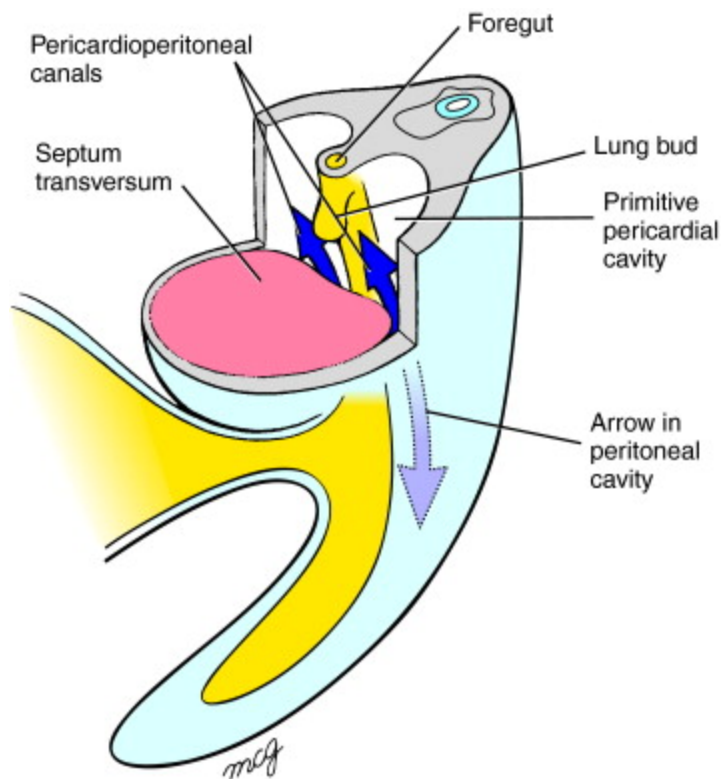
The process involves the formation of a **foregut** at the cranial end a **hindgut** at the caudal end and an open **midgut** that is the last to fuse and stays connected to the yolk sac via the **vitelline duct** (yolk stalk)



## Embryonic folding

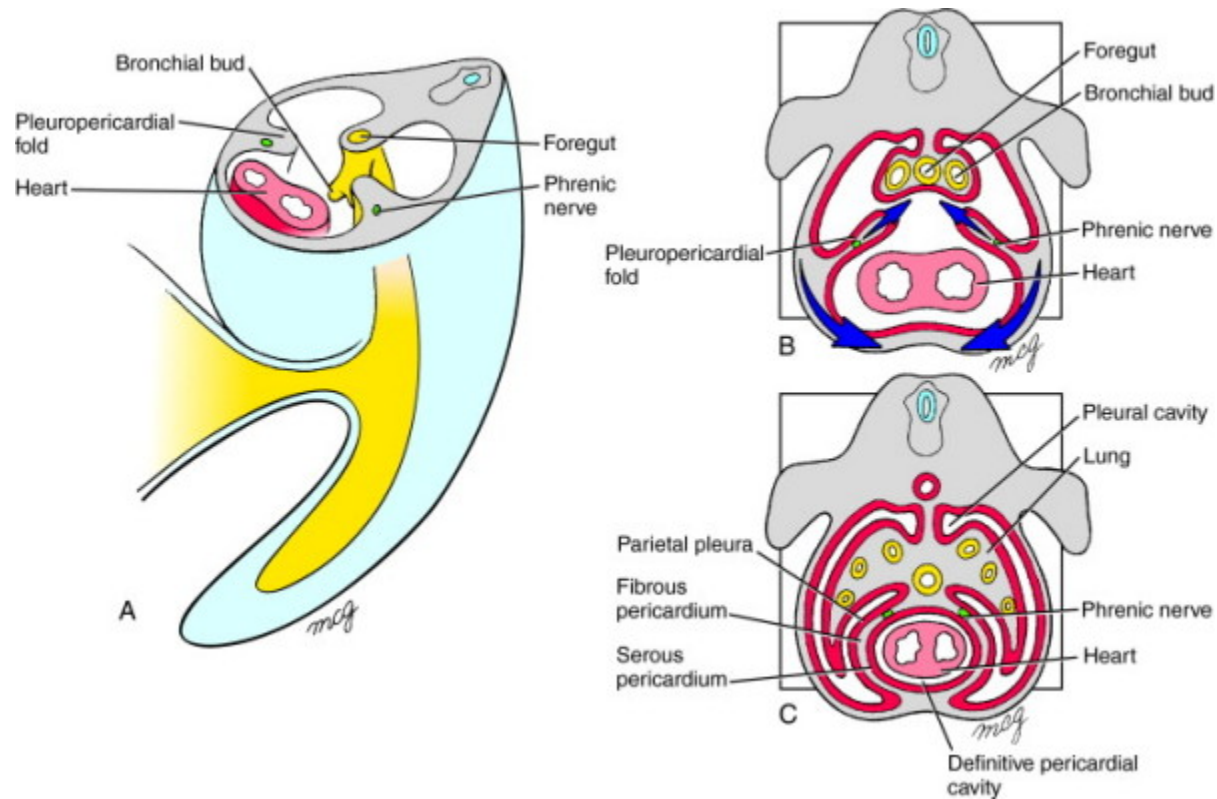
The 4th week also sees the development of three partitions that subdivide the coelom into the pericardial, pleural and peritoneal cavities. First the **septum transversum** divides the peritoneal cavity from the **primitive pericardial cavity**.

Schoenwolf: Larsen's Human Embryology, 4th ed.  
Copyright © 2008

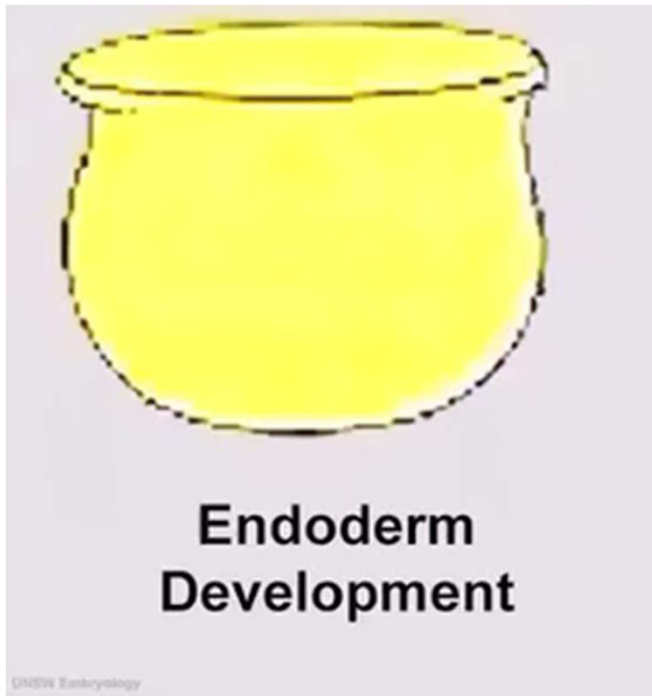


The septum transversum provides the first subdivision of the peritoneal and primitive pericardial cavity

The second subdivision of the coelom occurs in the thoracic cavity through the growth and fusion of the **pleuropericardial folds** during the 5<sup>th</sup> week. The roots of the pleuropericardial folds migrate ventromedially thus extending the pleural cavities around the whole thorax

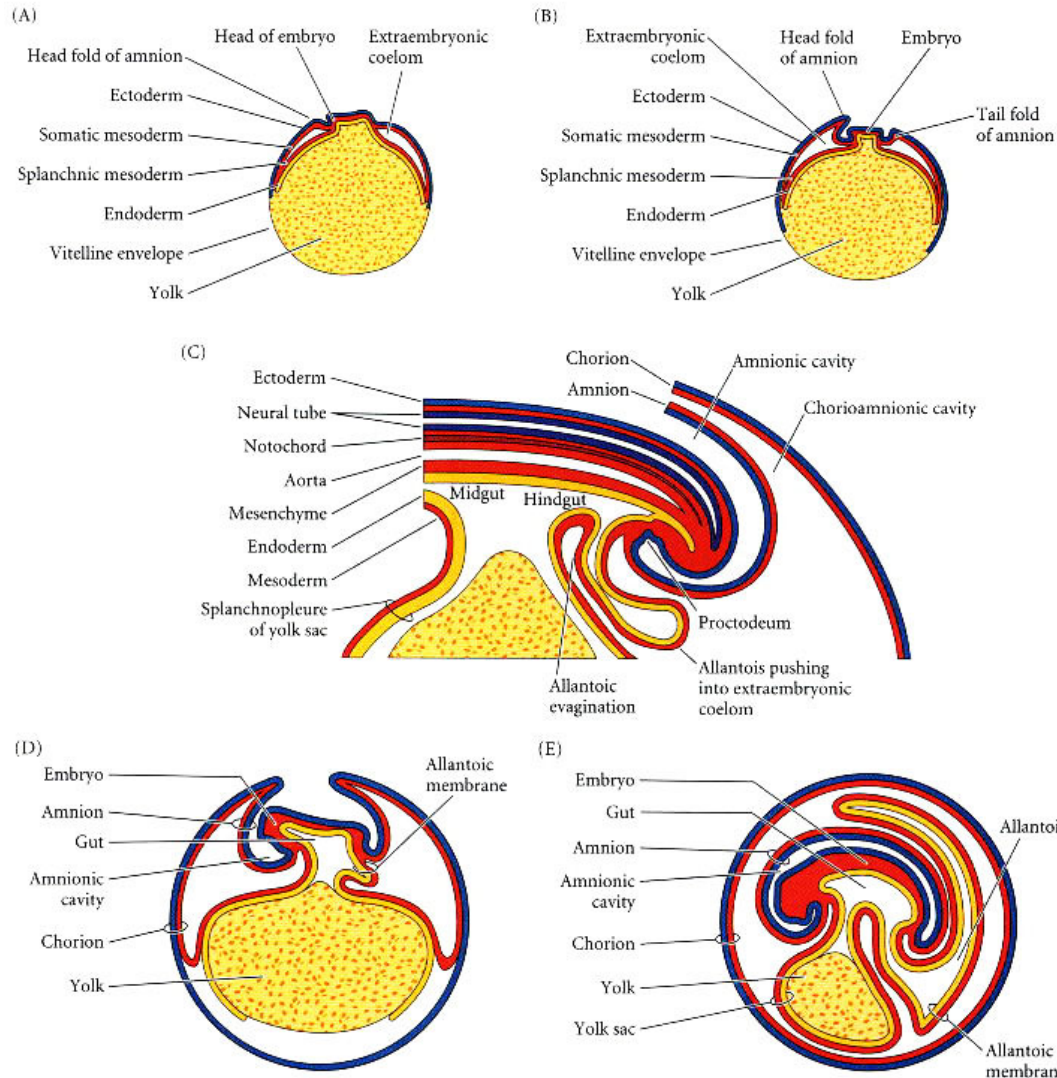


Schoenwolf: Larsen's Human Embryology, 4th ed.  
Copyright © 2008



Change in shape of the space enclosed by the endoderm and yolk sac during the 4<sup>th</sup> week

## Some of the important transient structures in egg-laying organisms

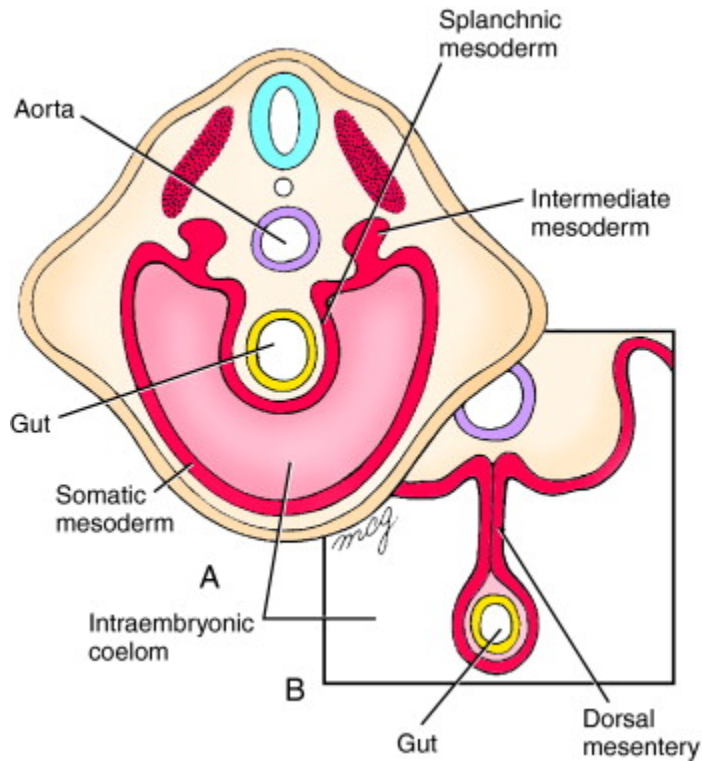


### In the chick

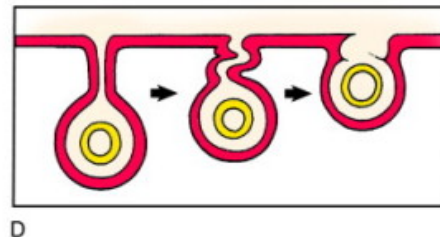
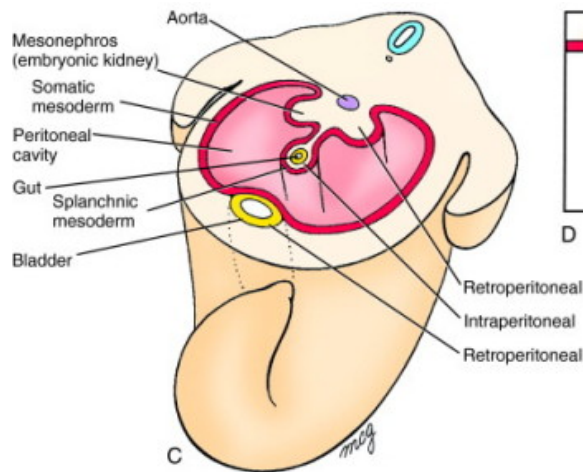
The endoderm is exposed to the yolk and formation of the gut involves gradual incorporation and pinching off of the **yolk sac** into the midgut.

The **allantois** (*sausage shaped Gk*) is outgrowth of the hindgut that is involved in the storage of nitrogenous waste and gas exchange

Developmental Biology. 6th edition.  
 Gilbert SF.  
 Sunderland (MA): [Sinauer Associates](http://www.wiley.com); 2000.



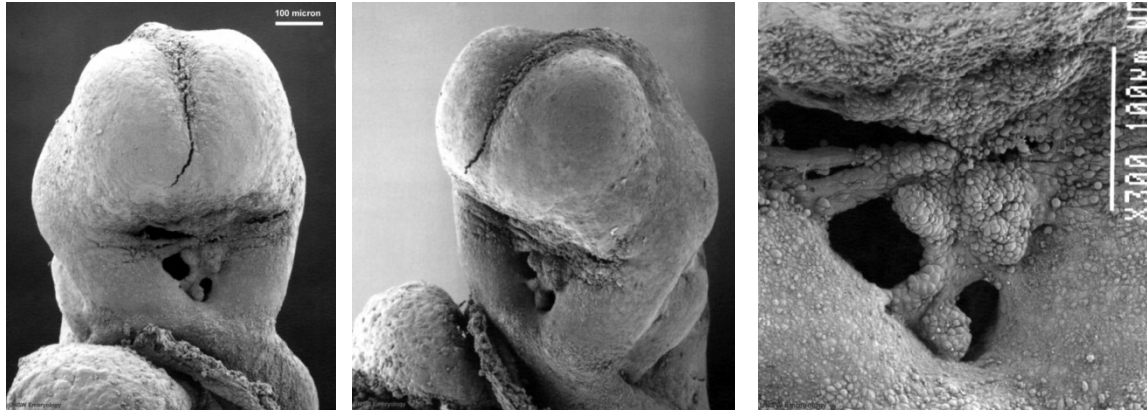
In the developing peritoneal cavity the gut tube is initially attached to the dorsal body wall. Then the medial mesenchyme starts to disperse bringing the splanchnic mesoderm together behind the gut tube to form a bilayered **dorsal mesentery**.



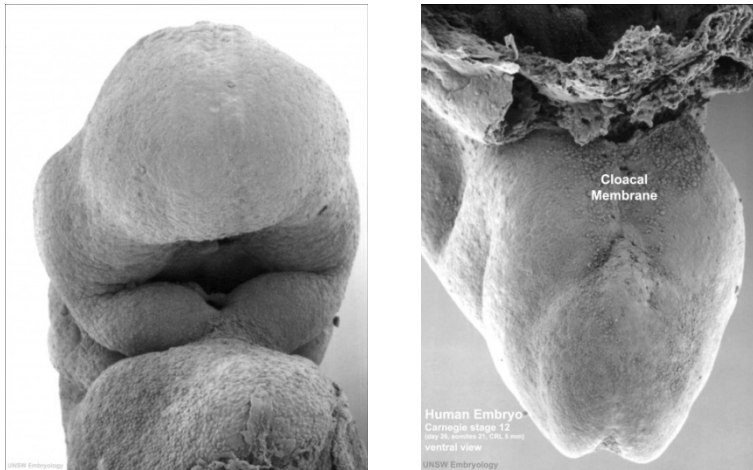
Some of the organs develop in the body wall and are wrapped in a layer of serous membrane. These are called **retroperitoneal** meaning they are behind the peritoneum (seen from the perspective of the inside). In some positions, the gut tube also becomes retroperitoneal through the regression of the mesentery: ascending and descending colon, duodenum and pancreas are **secondarily retroperitoneal**



Degeneration of the oropharyngeal (buccopharyngeal) membrane.

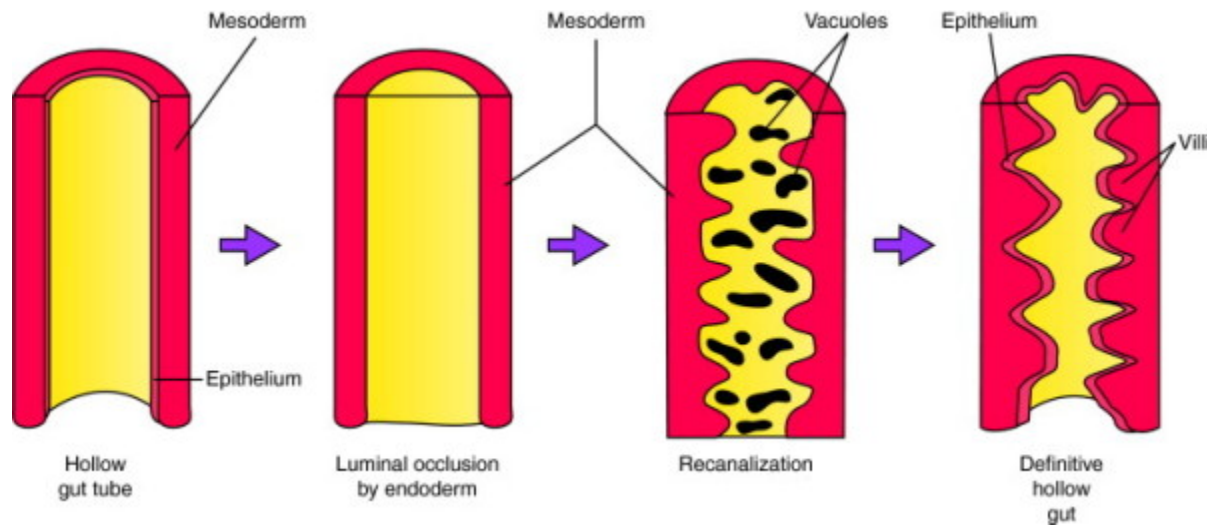


Stage 11, 25 days (<4 weeks)



Stage 12, 26 days (<4 weeks)

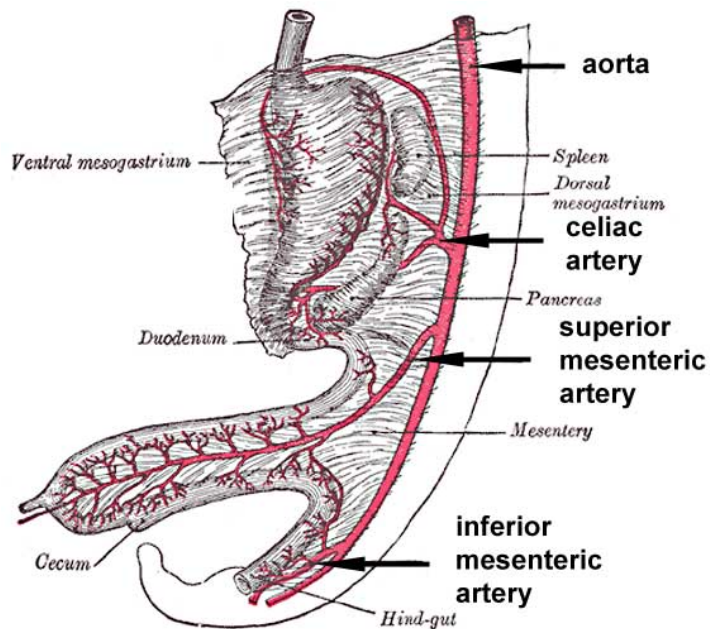
## Recanalization of the gut tube



By week 6, proliferation of the endodermal lining occludes the gut lumen. Recanalization is complete by wk 9 through the expansion of internal vacuoles. Projections of mesoderm near the site of vacuoles drives villi development.

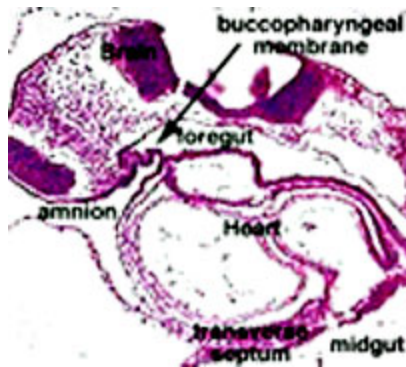
**Schoenwolf: Larsen's Human Embryology, 4th ed.**  
Copyright © 2008

## GIT divisions and blood supply



**During the 4th week the 3 distinct portions (fore-, mid- and hind-gut) extend the length of the embryo and will contribute different components of the GIT.**

- These 3 divisions are also later defined by the vascular (artery) supply to each of these divisions.
- The large **mid-gut** is generated by lateral embryonic folding which "pinches off" a pocket of the yolk sac, the 2 compartments continue to communicate through the vitelline duct.
- 
- The **oral cavity (mouth)** is formed
  - following breakdown of the buccopharyngeal membrane (oropharyngeal, oral membrane)
  - contributed to mainly by the pharynx lying within the pharyngeal arches.
  - opening of the GIT means that it contains amniotic fluid, which is also swallowed later in development.

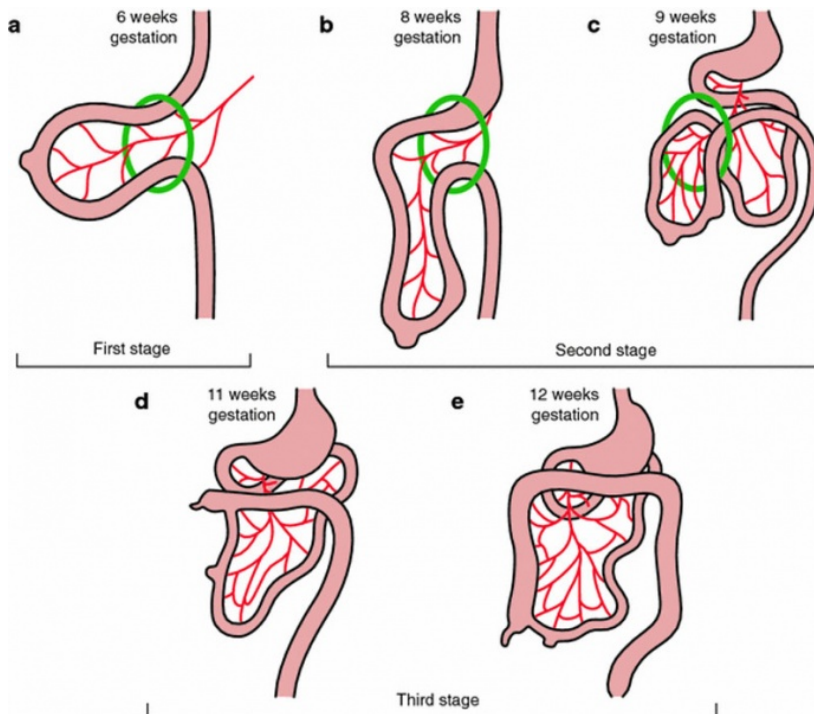


## Foregut

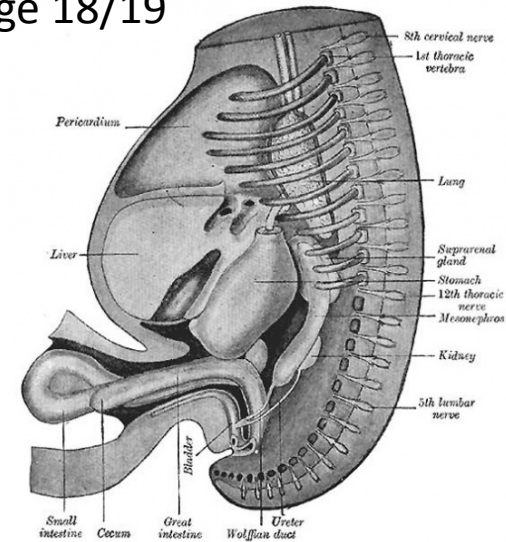
- Oral cavity
- Pharynx
- Oesophagus
- Respiratory diverticulum (a ventral bud arising at this level, covered in next lecture).
- Stomach
- About half of the duodenum

# Midgut

- Starting at part of the duodenum, ileum (small intestine), jejunum, and part of the colon (large intestine).
- Much of the **midgut is herniated** at the umbilicus external to the abdomen through development. A key step in development is the rotation of this midgut that must occur to place the GIT in the correct abdominal position with its associated mesentery.
- The **mesenteries** of the GIT are generated from the common **dorsal mesentery**, with the ventral mesentery contributing to the **lesser omentum** and **falciform ligament**.

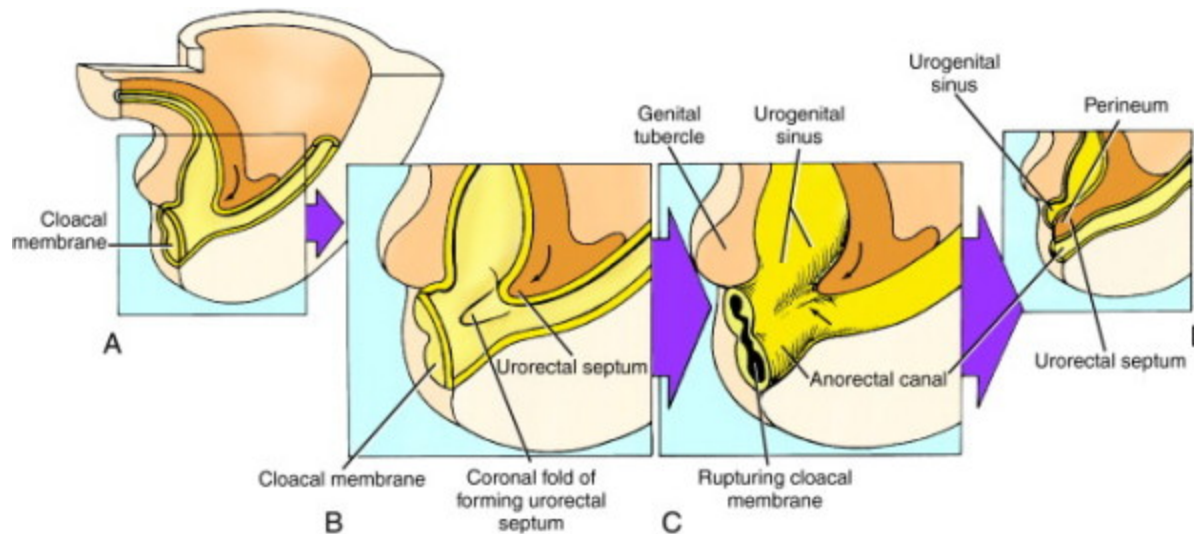


Carnegie stage 18/19  
Week 7



# Hindgut

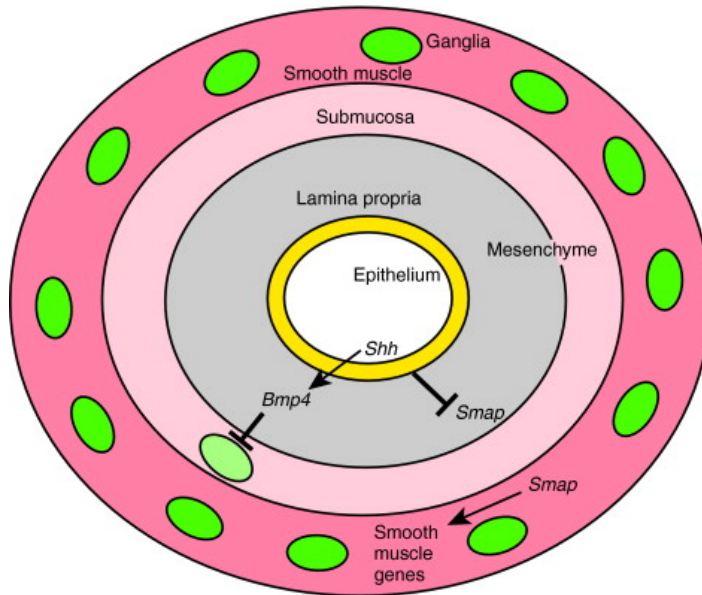
- Forms the - distal transverse colon, descending colon, sigmoid colon, rectum and cloaca.
- The **cloaca** subdivides into the ventral urogenital sinus and a posterior anorectal canal.



4-6 weeks The urorectal septum divides the cloaca, the cloacal membrane ruptures and the tip of the urorectal septum forms the perineum

## Radial patterning of the gut tube

Shh emanating from the endoderm inhibits smooth muscle activating protein and BMP4 induced by SHH limits enteric neuronal differentiation to the outer layer of the gut wall



## Stomach

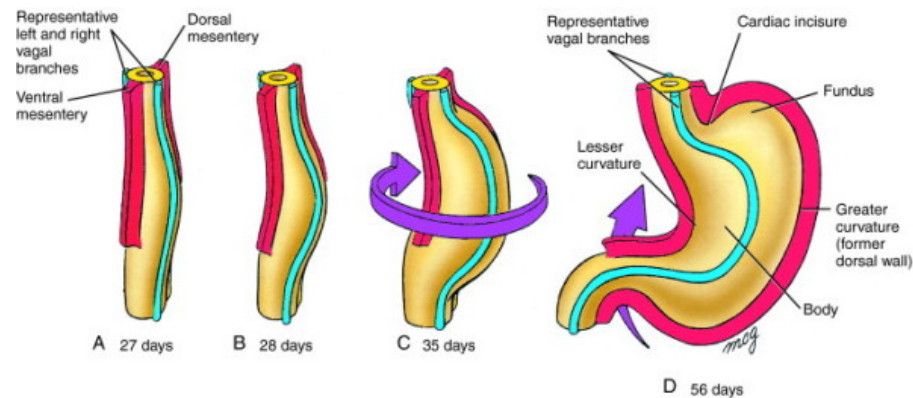
During week 4 where the stomach will form, the GIT tube begins to dilate (forming an enlarged lumen in the tube).

In the stomach region the gut tube stays attached to the ventral body wall via the septum transversum which thins in the caudal region to form the **ventral mesentery** connecting the stomach and liver to the ventral body wall.

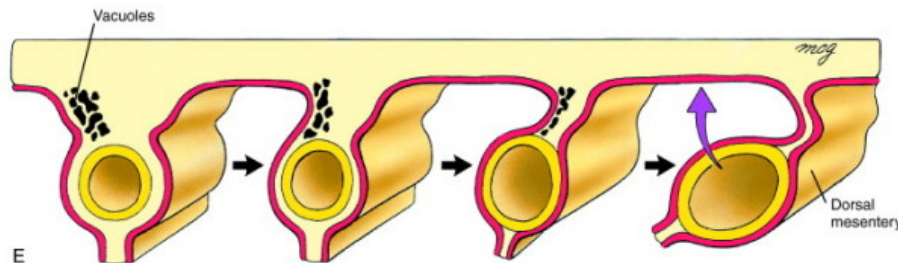
During the **5<sup>th</sup> week** the dorsal wall grows more rapidly than ventral, establishing the greater curvature of the stomach.

**7-8 weeks** a second rotation (of 90 degrees) occurs on the longitudinal axis establishing the adult orientation of the stomach.

The stomach then attaches to the dorsal body wall becoming **secondarily retroperitoneal**.



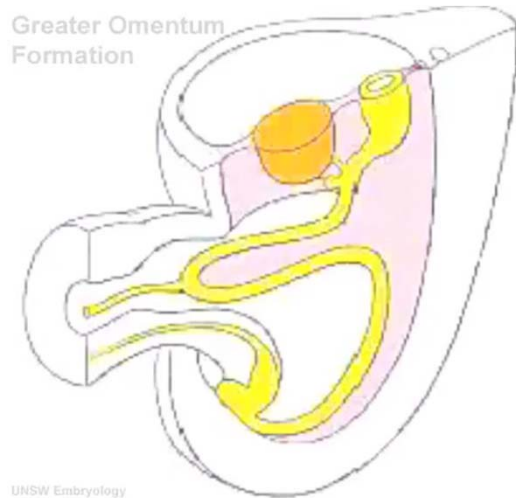
Schoenwolf: Larsen's Human Embryology, 4th ed.  
Copyright © 2008



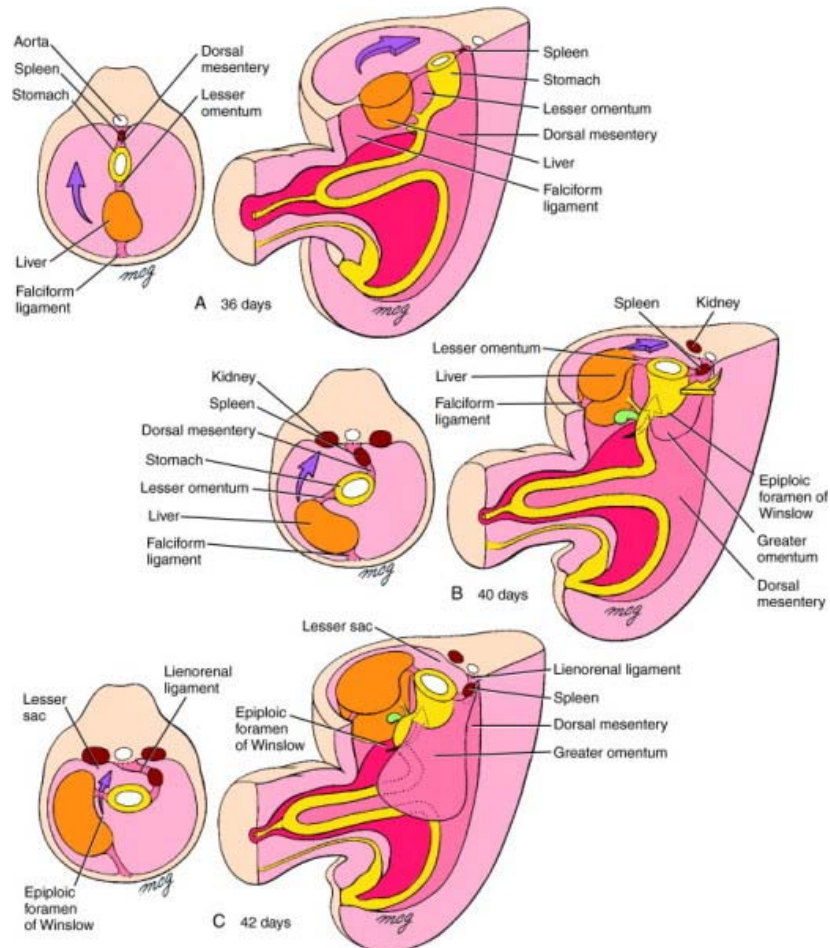


The [greater omentum](#) begins as an extended fold of the [dorsal mesogastrium](#) that continues to grow and extend down into the peritoneal cavity and eventually lies anterior to the small intestines. This fold of mesentery will also fuse to form a single sheet.

Greater Omentum Formation



UNSW Embryology



Schoenwolf: Larsen's Human Embryology, 4th ed.  
Copyright © 2008

## Liver

- **Day 22** an endodermal thickening begins in the wall of the duodenum called the **hepatic plate**.
- The cells of the hepatic plate proliferate to form the **hepatic diverticulum** which grows into the septum transversum.
- Hepatic diverticulum gives rise to **liver cords** which become the **hepatocytes**.
- The supporting stromal cells of the liver come from splanchnic mesoderm near the stomach
- The liver is also a fetal haematopoietic organ. The blood stem cells are derived from mesenchyme of the septum transversum.
- **Day 26** endodermal thickening appears on the ventral side of the duodenum just caudal to the hepatic diverticulum called the **cystic diverticulum** which will form the gall bladder and the cystic duct.

## Pancreas

- **Day 26:** another duodenal bud develops opposite to the hepatic diverticulum called the **dorsal pancreatic bud**, which grows into the dorsal mesentery.
- After a few days a second **ventral pancreatic bud** develops just caudal to the developing cystic diverticulum.
- As the cystic diverticulum extends to create the bile duct the ventral pancreatic bud becomes connected to the proximal end.
- The dorsal pancreatic bud becomes the **head, tail and body** of the pancreas whereas the ventral pancreatic bud creates the **uncinate process** of the pancreas.
- These duct systems fuse eventually to form the main pancreatic duct which meets the bile duct and they empty into the duodenum at the major duodenal papilla.

## Spleen

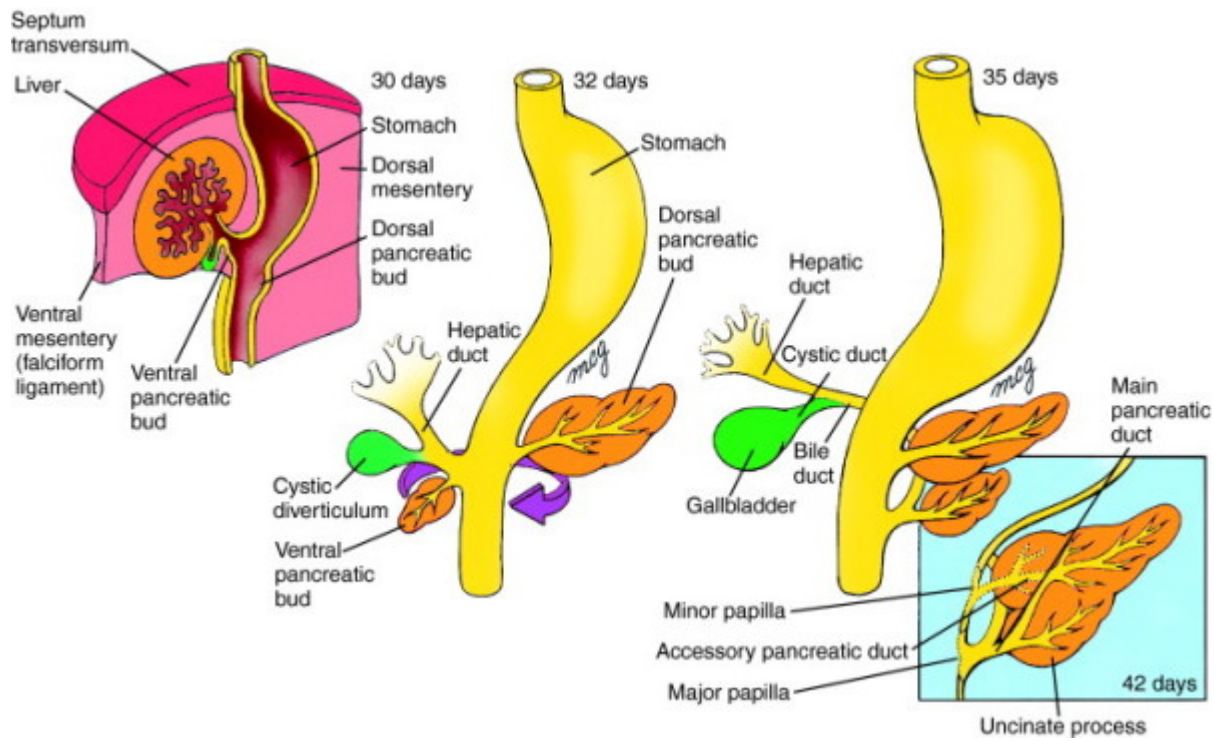
The spleen is formed from mesodermal derivatives

It develops within the dorsal mesogastrium not from gut tube endoderm

It initially forms as a mesenchymal condensation in the 5<sup>th</sup> week

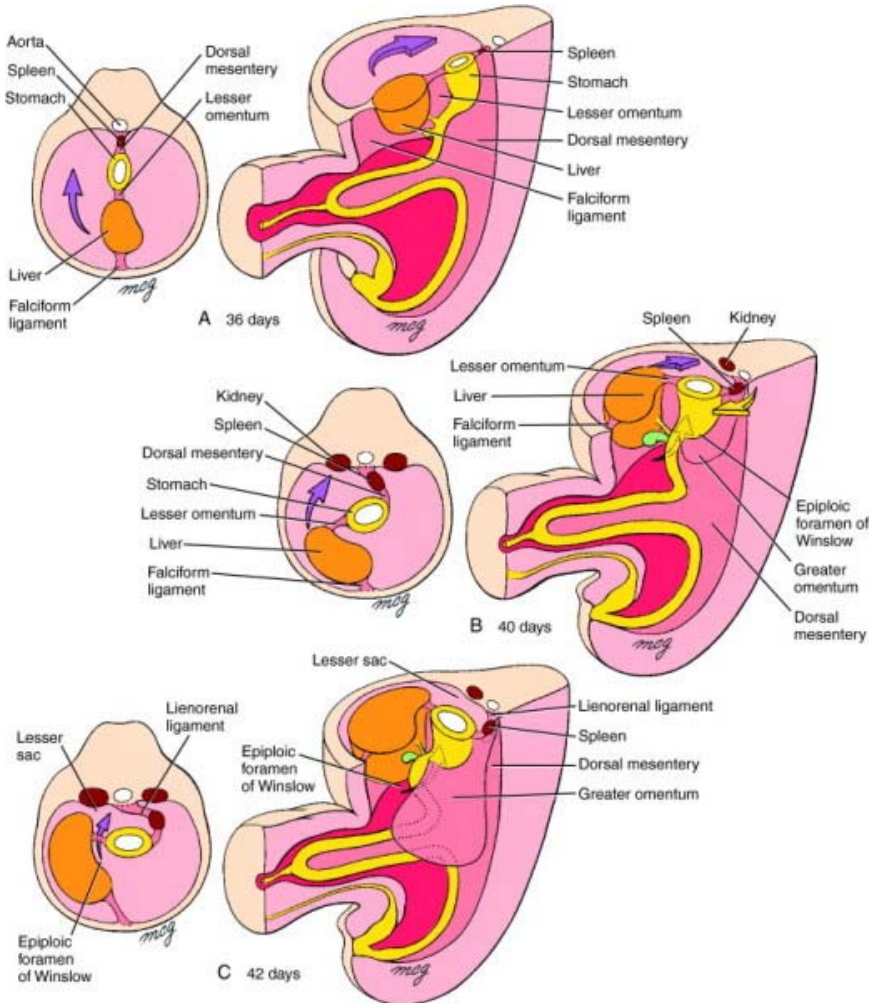
The spleen translocates to the left side during the rotation of the stomach

The spleen is initially a haematopoietic organ and only becomes a lymphoid organ later on at 15-18 weeks when lymphoid colonization occurs



**Schoenwolf: Larsen's Human Embryology, 4th ed.**  
 Copyright © 2008

# Rotation of the stomach and repositioning of the liver and spleen



Schoenwolf: Larsen's Human Embryology, 4th ed.  
 Copyright © 2008