MD Program
UNIVERSITY OF TORONTO

Anatomy

UNIT 4: Abdomen, Pelvis & Perineum
Lab 11

CLICK TO ENTER

Lab 11: Exercise Selection

Select an exercise to begin:

Pre-lab SLM

- 11A PRELAB SLM: INNERVATION OF THE GI SYSTEM

Lab 11 Exercises

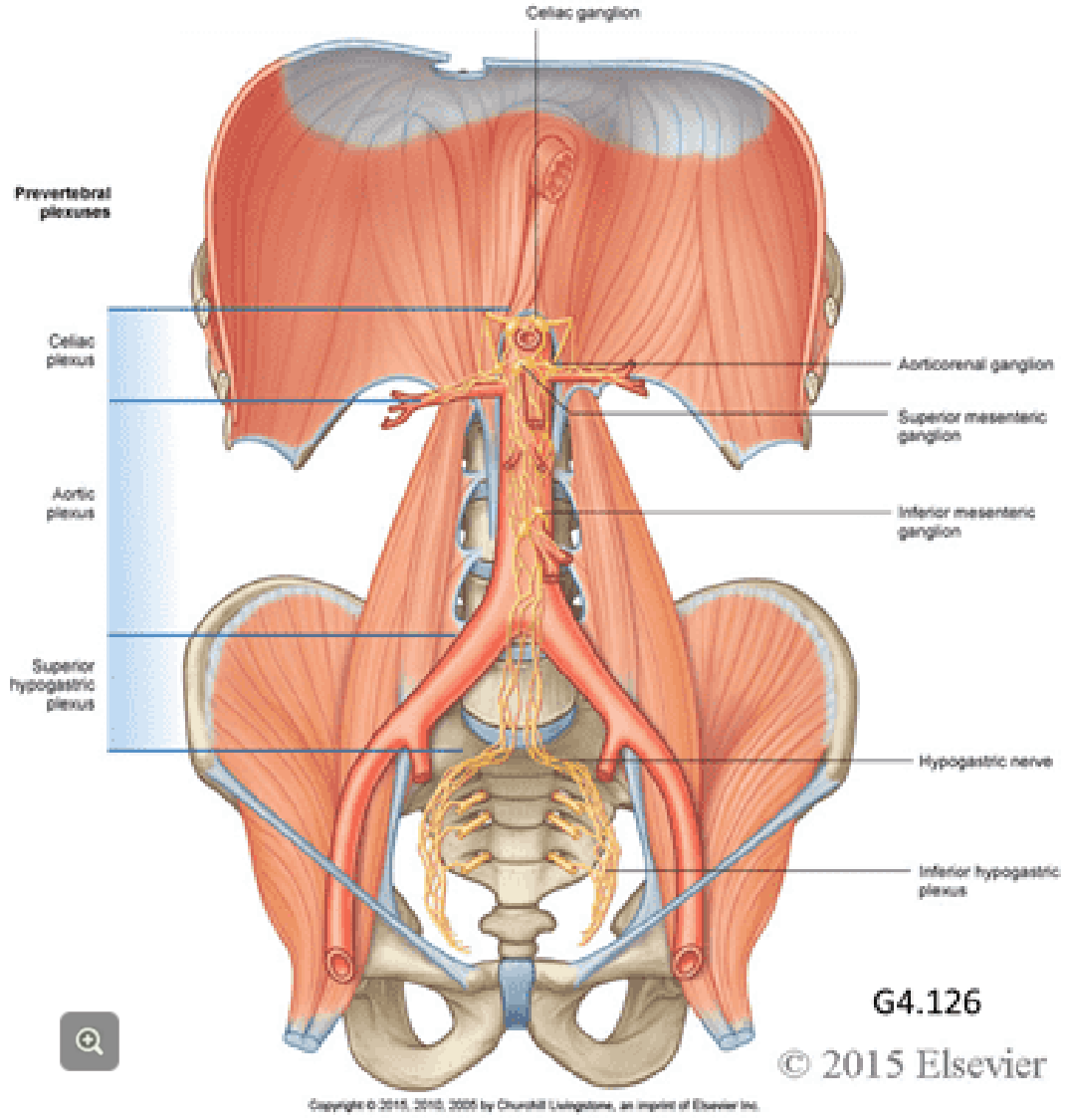
- 11.1 DISSECTION OF THE FOREGUT
- 11.2 STUDY OF PROSECTIONED ORGANS

If you finish any exercise early…

- 11.3 FIELD TRIP
- QUIZLANDIA 11

11A Pre-Lab SLM: Innervation of the GI System

Complete this pre-lab SLM **prior to** Lab 11. You will be quizzed on its contents at the start of the lab period.

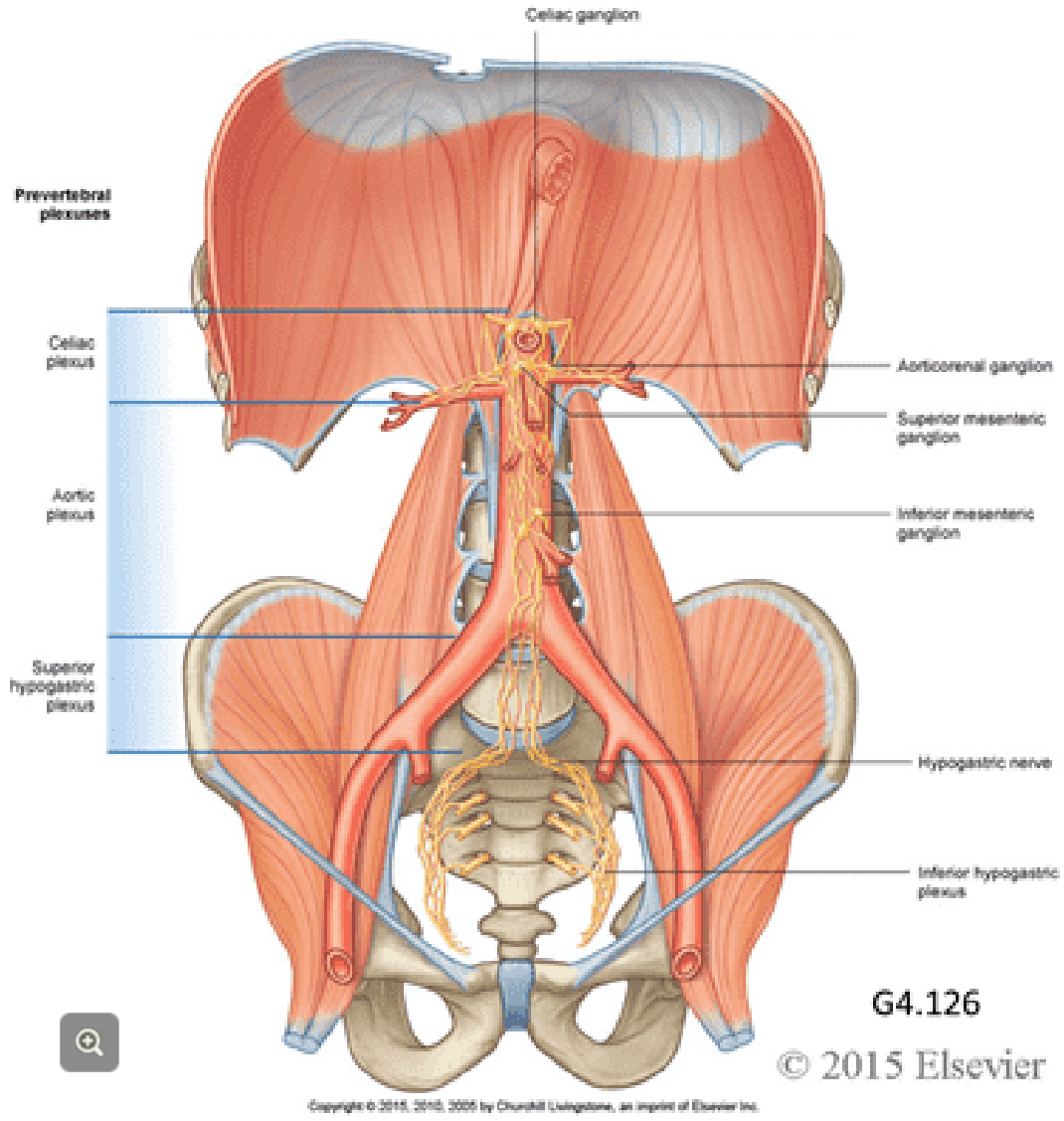


PREVIOUS

NEXT

When you have completed this self-learning module, you will be able to describe:

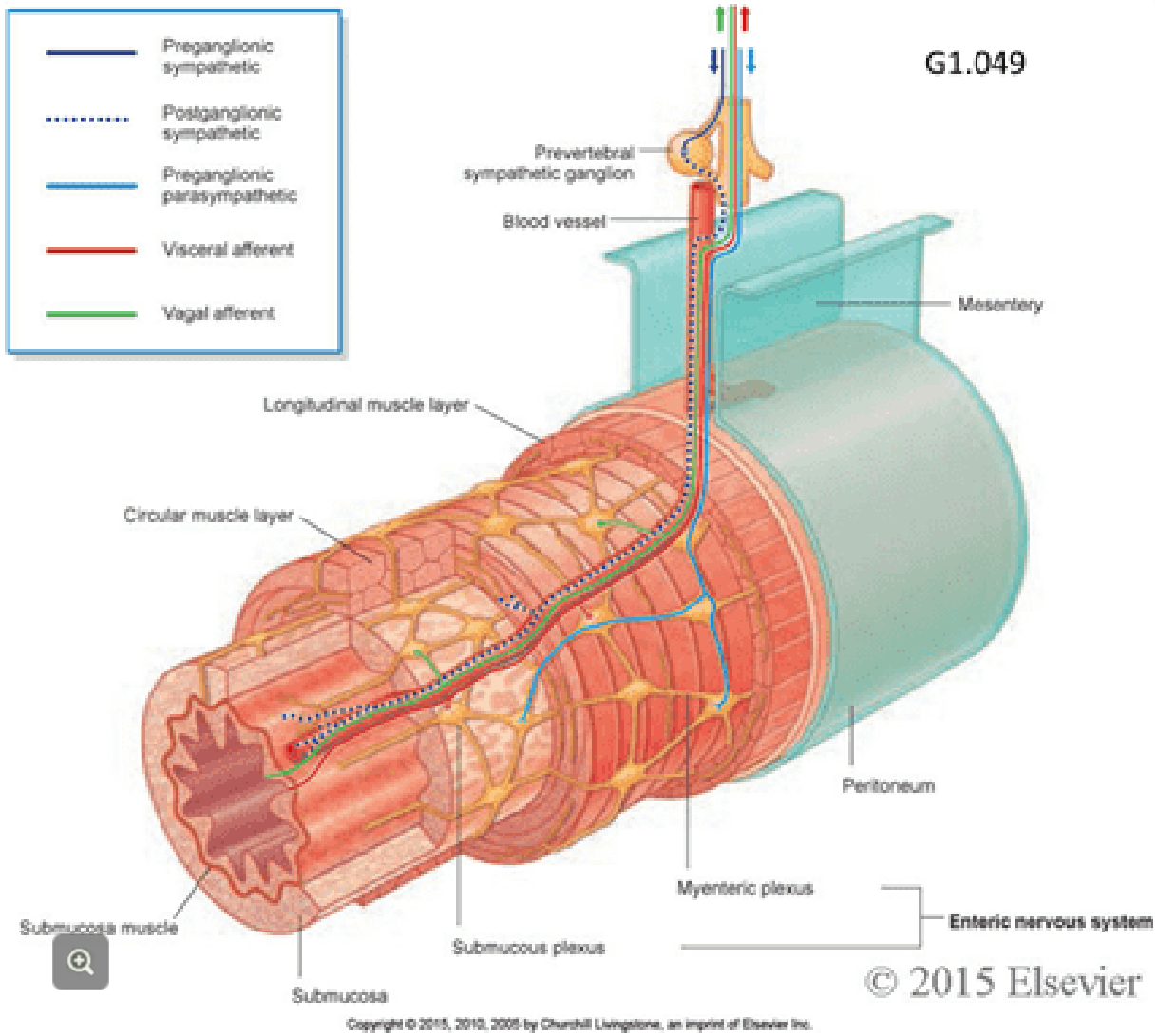
- the autonomic nerve supply to the organs of the abdomen
- the typical patterns of referred pain from the organs of the GI system



As also discussed in H13, **The Histology of the Digestive System Part 1**, the digestive system includes the **enteric nervous system**. It consists of the **submucosal (Meissner's) and myenteric (Auerbach's) plexuses**, the **fibres that connect them** and the **fibres that innervate the tissues of the gut wall**.

The enteric nervous system functions autonomously to control activity **within and between regions of the gut**, activities such as **gut motility, secretion and vascular tone**. It does, however, receive input from, and is modulated by, the autonomic nervous system. **Gut motility and secretion are increased and decreased, respectively, by parasympathetic and sympathetic input**.

Sensory information from the gut wall feeds back to the CNS. Along most of the length of the gut, **visceral pain** is conducted centrally alongside **sympathetic efferents**. **Homeostatic feedback** travels with **parasympathetic efferents**.



The enteric nervous system receives **sympathetic postganglionic** and **parasympathetic preganglionic** inputs from **autonomic plexuses** of the abdomen and pelvis. These are the **prevertebral plexuses** (inc. the **celiac, aortic and superior hypogastric plexuses**), and, in the pelvis, the **inferior hypogastric plexus**.

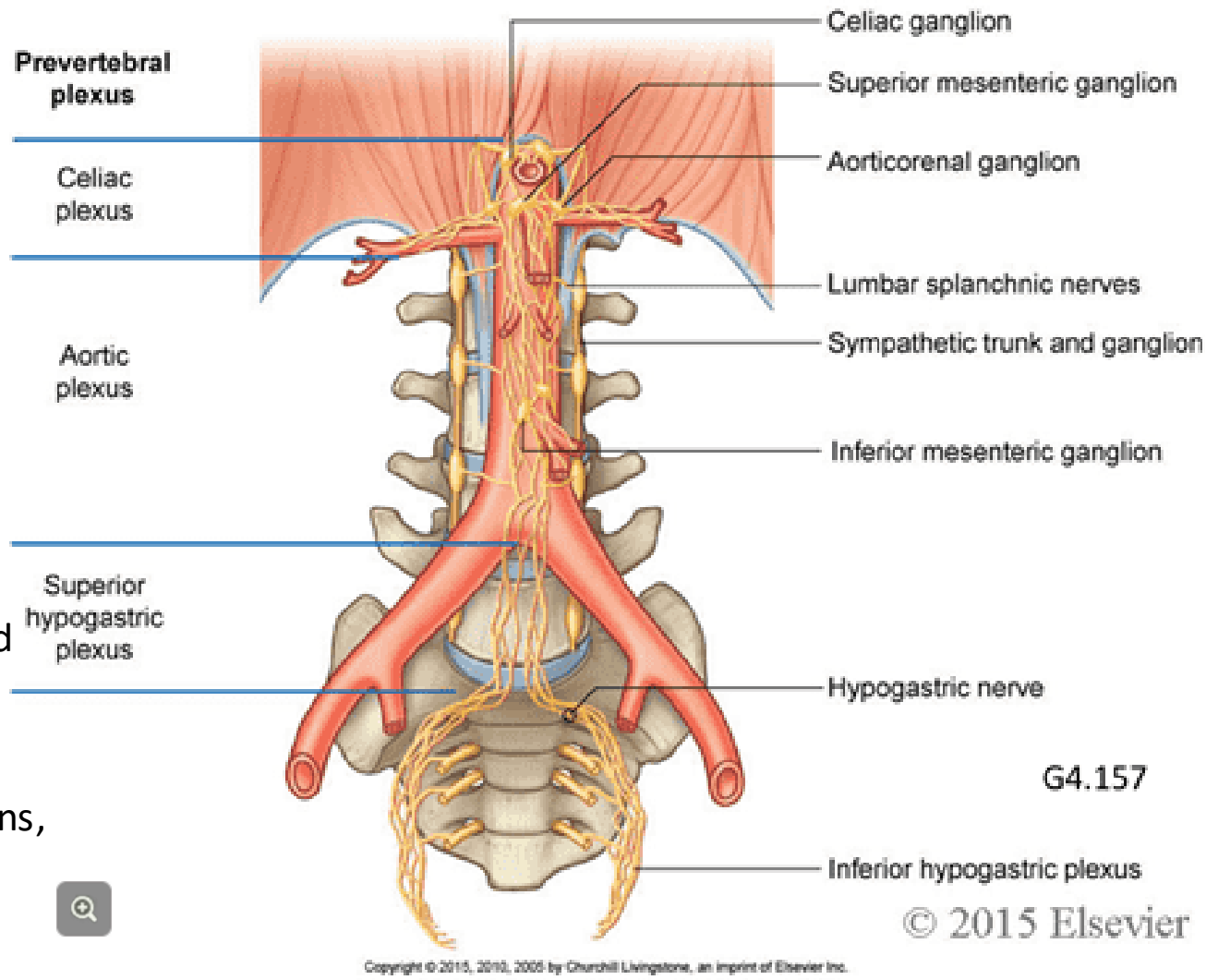
Sympathetic ganglia are associated with these mixed (sympathetic and parasympathetic) autonomic plexuses. The larger ganglia are named.

The **celiac, superior mesenteric and aorticorenal ganglia** are considered components of the **celiac plexus**.

The **inferior mesenteric ganglion** is a component of the **aortic plexus**.

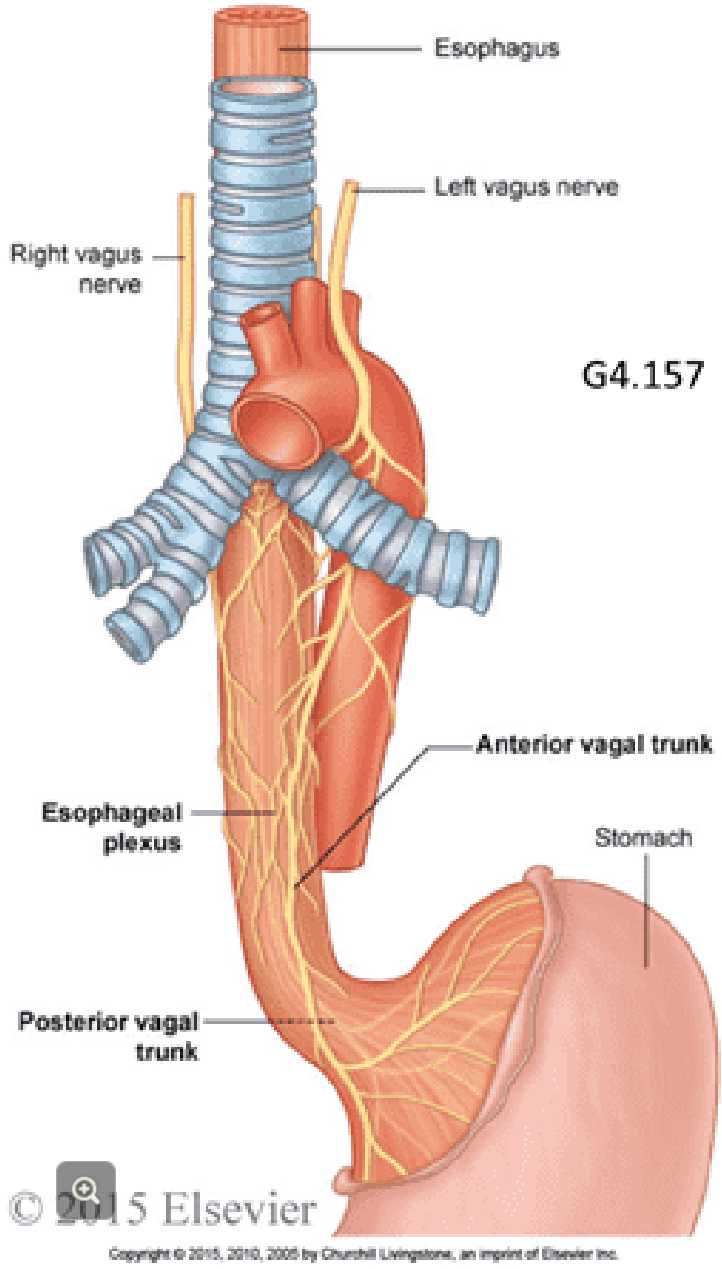
Numerous, **smaller, unnamed ganglia** are distributed throughout these plexuses, including in the **superior** and **inferior hypogastric plexuses**.

Parasympathetic ganglia, containing parasympathetic postganglionic neurons, **are microscopic components of the submucosal and myenteric plexuses within the walls of the GI tract**.



The **vagus nerve**, cranial nerve X, supplies parasympathetic preganglionic fibres to the foregut and midgut; i.e. to the GI tract **as far as the distal portion of the transverse colon**.

The fibres of the **left and right vagus nerves overlap in the esophageal plexus**. The esophageal plexus gives rise to **anterior and posterior vagal trunks**, each of which includes fibres from both the left and right vagus nerves. The vagal trunks are named according to their position relative to the esophagus, and they pass into the abdomen **through the esophageal hiatus** of the diaphragm.

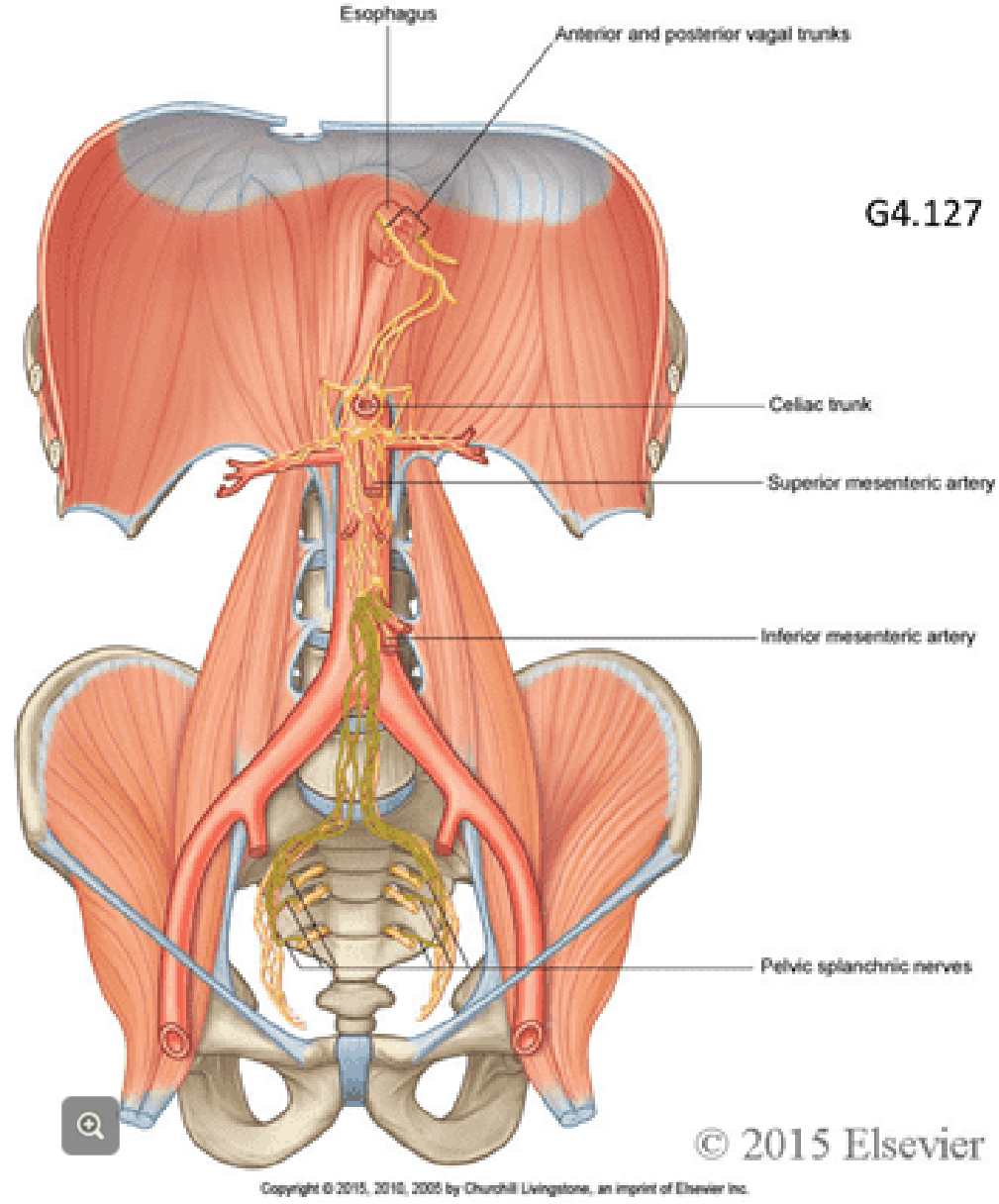


The parasympathetic innervation of the **stomach** is largely derived from the **anterior vagal trunk**.

The vagal contribution to the **prevertebral plexus**, on the other hand, is primarily derived from fibres of the **posterior vagal trunk**.

Vagal fibres from the prevertebral plexus pass along the celiac and superior mesenteric arteries, and their branches, to supply the remaining organs of the **foregut, as well as those of the midgut**.

In the gut wall, vagal fibres synapse onto postganglionic parasympathetic neurons in the **submucosal (Meissner's)** and **myenteric (Auerbach's) plexuses**, to **control secretion and motility, respectively**.

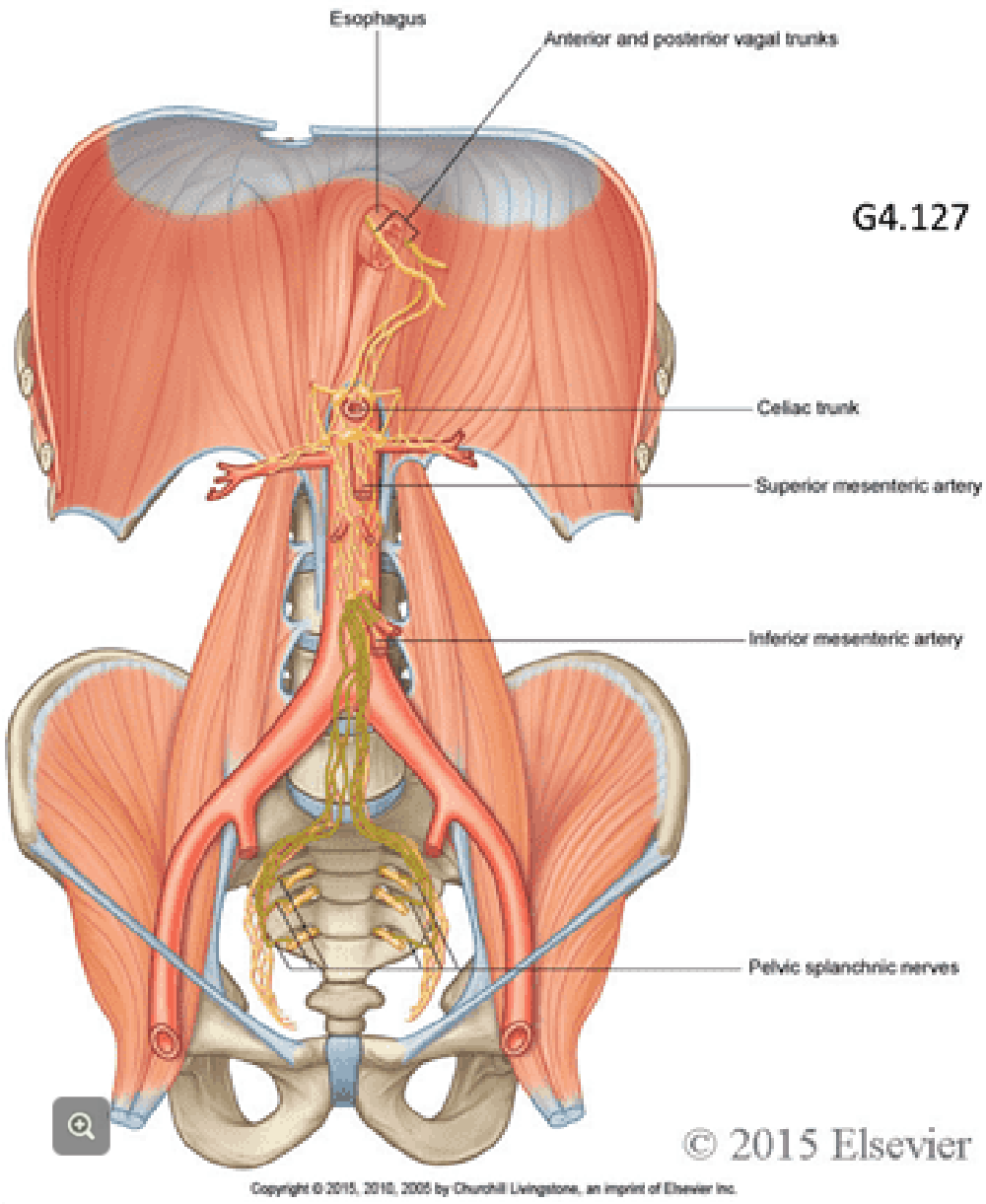


Parasympathetic innervation of the **hindgut and pelvic organs** originates from preganglionic neuronal cell bodies in the **S_2 - S_4 segments of the spinal cord**.

Axons arising from these neurons travel first with the S_2 - S_4 spinal nerves and their ventral rami, which **enter the pelvis through the anterior sacral foramen**. There, the parasympathetic preganglionic fibres **branch off the ventral rami** to form the **pelvic splanchnic nerves**. The pelvic splanchnic nerves contribute parasympathetic preganglionic fibres to the **inferior hypogastric plexus.**

From the inferior hypogastric plexus, some of these parasympathetic preganglionic fibres innervate **pelvic structures**. Others ascend through the **superior hypogastric plexus** to the **aortic plexus**. These fibres then travel along the **inferior mesenteric artery** to their target organs of the **hindgut**.

There again in the gut wall, parasympathetic preganglionic fibres synapse onto postganglionic parasympathetic neurons in the **submucosal (Meissner's)** and **myenteric (Auerbach's) plexuses**, to **control secretion** and **motility, respectively**.



Sympathetic preganglionic neurons destined to control **abdominal and pelvic targets** arise from spinal cord segments **T_5 to L_2**.

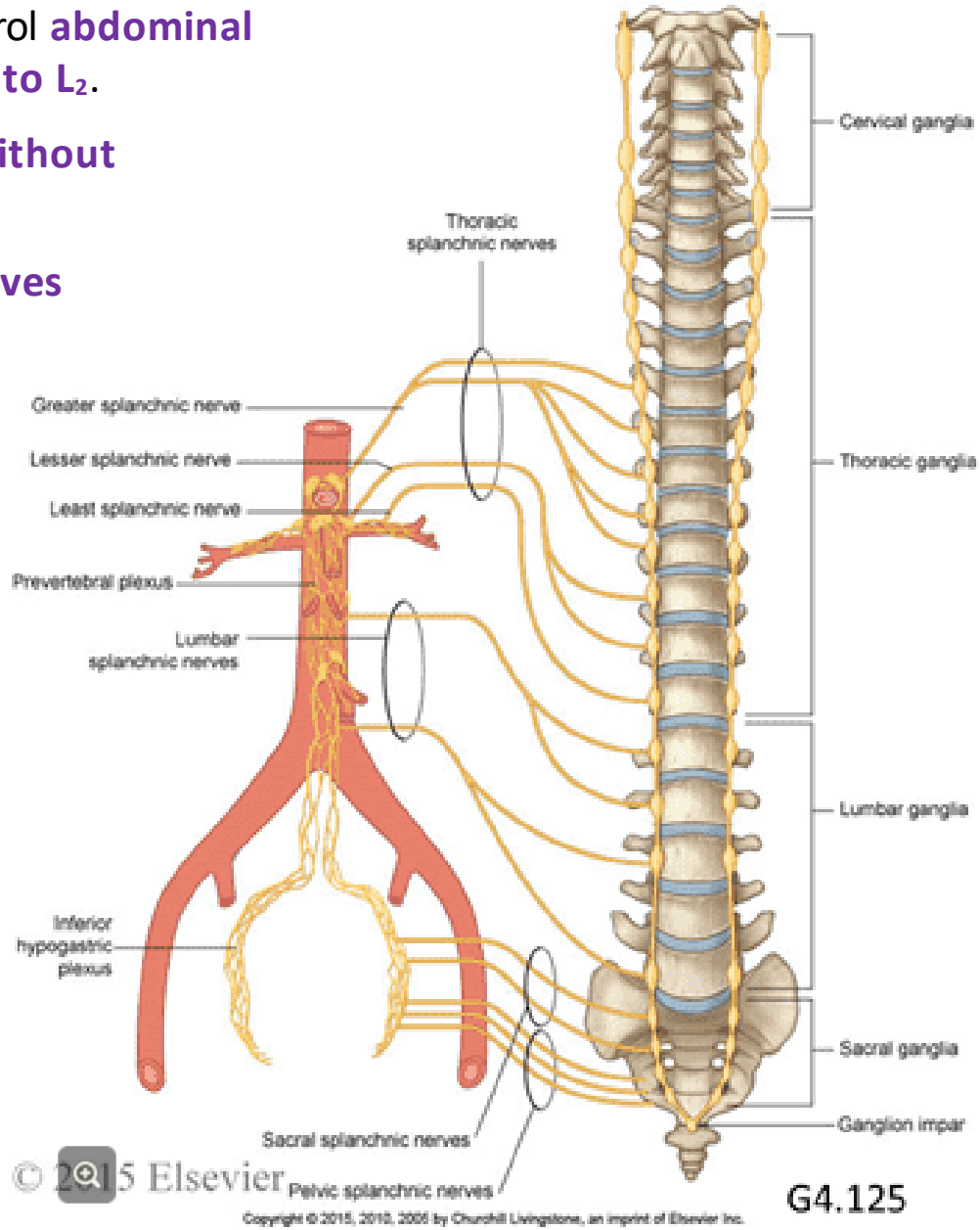
Their axons pass through sympathetic chain ganglia **without synapsing**, and then form the:

- **thoracic (greater, lesser and least) splanchnic nerves**
- **lumbar splanchnic nerves**
- **sacral splanchnic nerves**

which deliver **sympathetic preganglionic fibres** to the **autonomic plexuses** of the abdomen and pelvis.

There, these preganglionic axons synapse onto sympathetic postganglionic neuronal cell bodies contained within ganglia associated with these autonomic plexuses. Named ganglia are the **celiac, aorticorenal, superior mesenteric and inferior mesenteric ganglia**, although there are **numerous smaller, unnamed sympathetic ganglia** within the plexuses as well, including in the **superior** and **inferior hypogastric plexuses**.

Postganglionic sympathetic axons arise from these ganglia, enter the autonomic plexuses and **travel with** the **arteries** supplying the gut to their target organ.

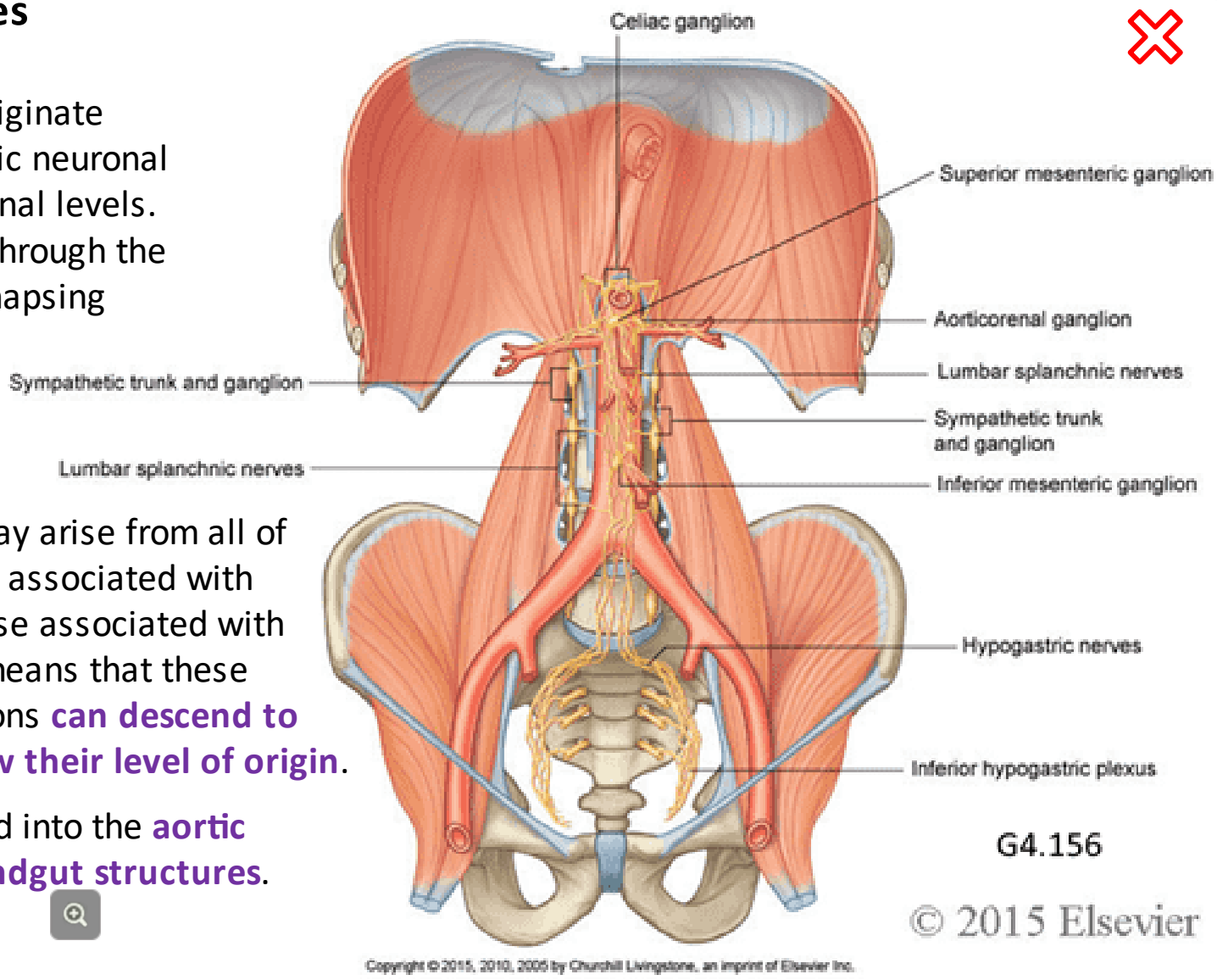


Lumbar Splanchnic Nerves

Lumbar splanchnic nerves originate from sympathetic preganglionic neuronal cell bodies at the L_1 and L_2 spinal levels. Axons of these neurons pass through the sympathetic chain without synapsing

Lumbar splanchnic nerves may arise from all of the sympathetic chain ganglia associated with lumbar vertebrae, not just those associated with the L_1 and L_2 vertebrae. This means that these sympathetic preganglionic axons **can descend to emerge from the chain below their level of origin**.

Lumbar splanchnic nerves feed into the **aortic plexus**. They largely target **hindgut structures**.

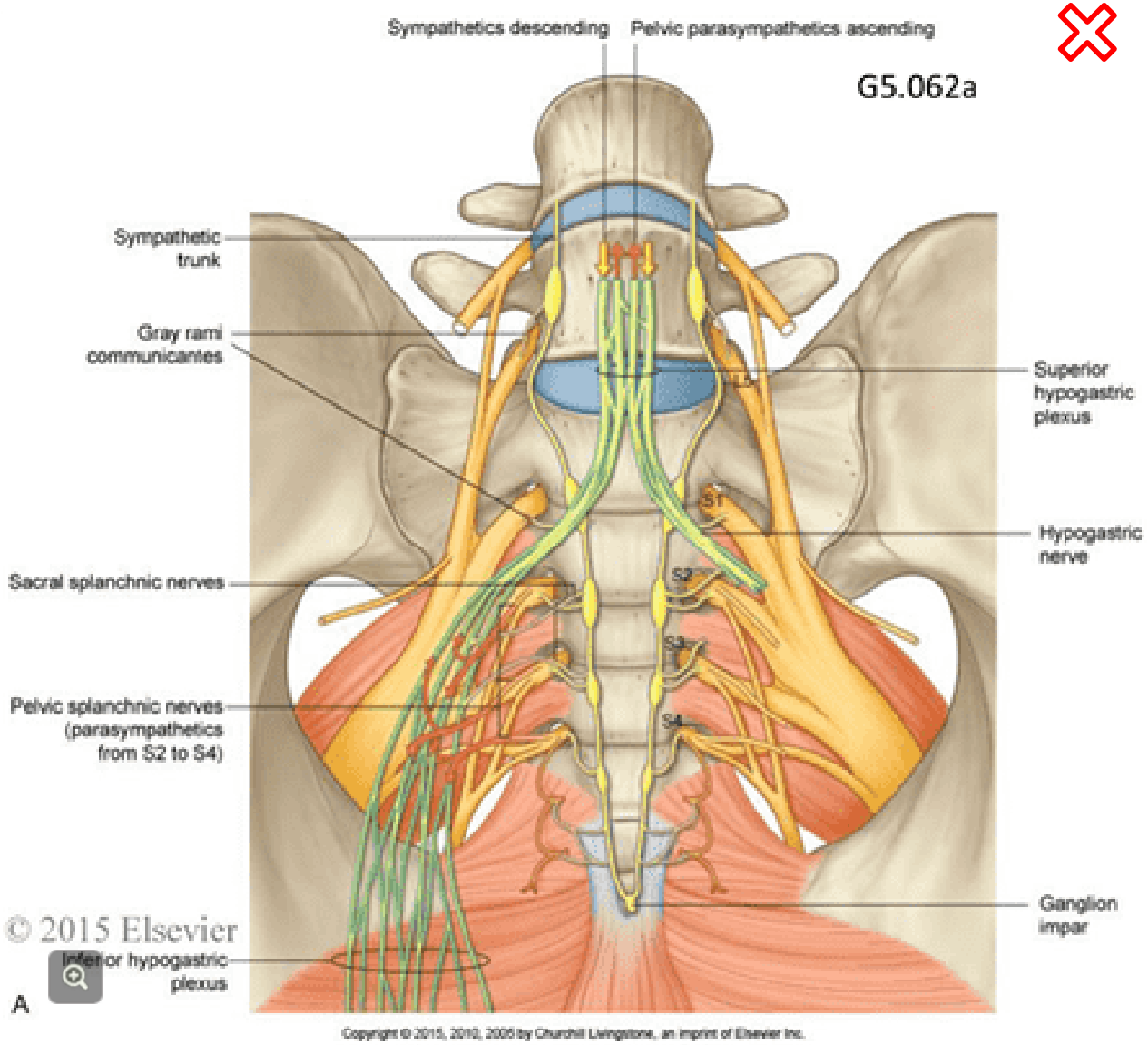


Sacral Splanchnic Nerves

Sacral splanchnic nerves originate from sympathetic preganglionic neuronal cell bodies at the L_1 and L_2 spinal levels. Axons of these neurons pass into the sympathetic chain and descend to sacral levels.

Sacral splanchnic nerves arise from the sympathetic chain ganglia associated with the sacrum. Thus, like some lumbar splanchnic nerves, these **axons descend to arise from the chain below their level of origin**.

Sacral splanchnic nerves feed into the **inferior hypogastric plexus**, where they synapse with postganglionic sympathetic neuronal cell bodies located within numerous small, unnamed ganglia. Their postsynaptic fibres largely target pelvic structures.



Sympathetic preganglionic neurons destined to control **abdominal and pelvic targets** arise from spinal cord segments **T_5 to L_2**.

Their axons pass through sympathetic chain ganglia **without synapsing**, and then form the:

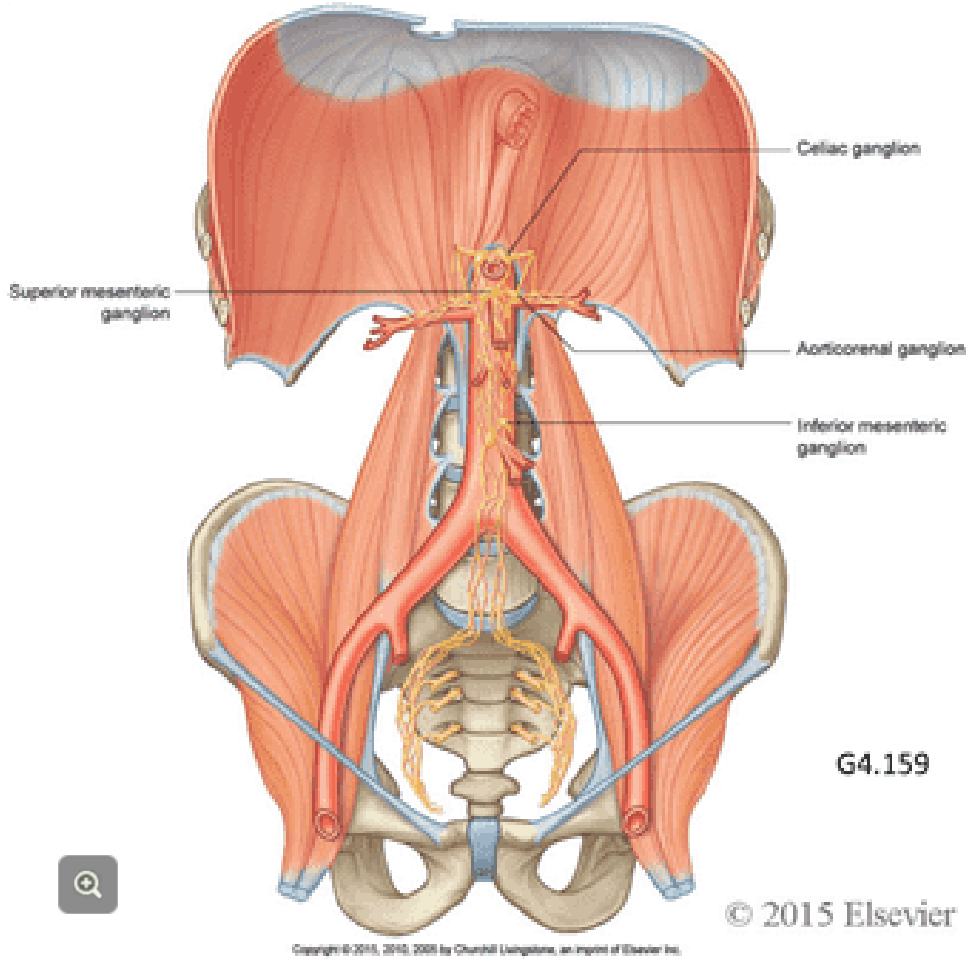
- **thoracic (greater, lesser and least) splanchnic nerves**
- **lumbar splanchnic nerves**
- **sacral splanchnic nerves**

which deliver **sympathetic preganglionic fibres** to the **autonomic plexuses** of the abdomen and pelvis.

There, these preganglionic axons synapse onto sympathetic postganglionic neuronal cell bodies contained within ganglia associated with these autonomic plexuses. Named ganglia are the **celiac, aorticorenal, superior mesenteric and inferior mesenteric ganglia**, although there are **numerous smaller, unnamed sympathetic ganglia** within the plexuses as well, including in the **superior** and **inferior hypogastric plexuses**.

Postganglionic sympathetic axons arise from these ganglia, enter the autonomic plexuses and **travel with** the **arteries** supplying the gut to their target organ.

Named Sympathetic Ganglia of the Abdomen and Pelvis

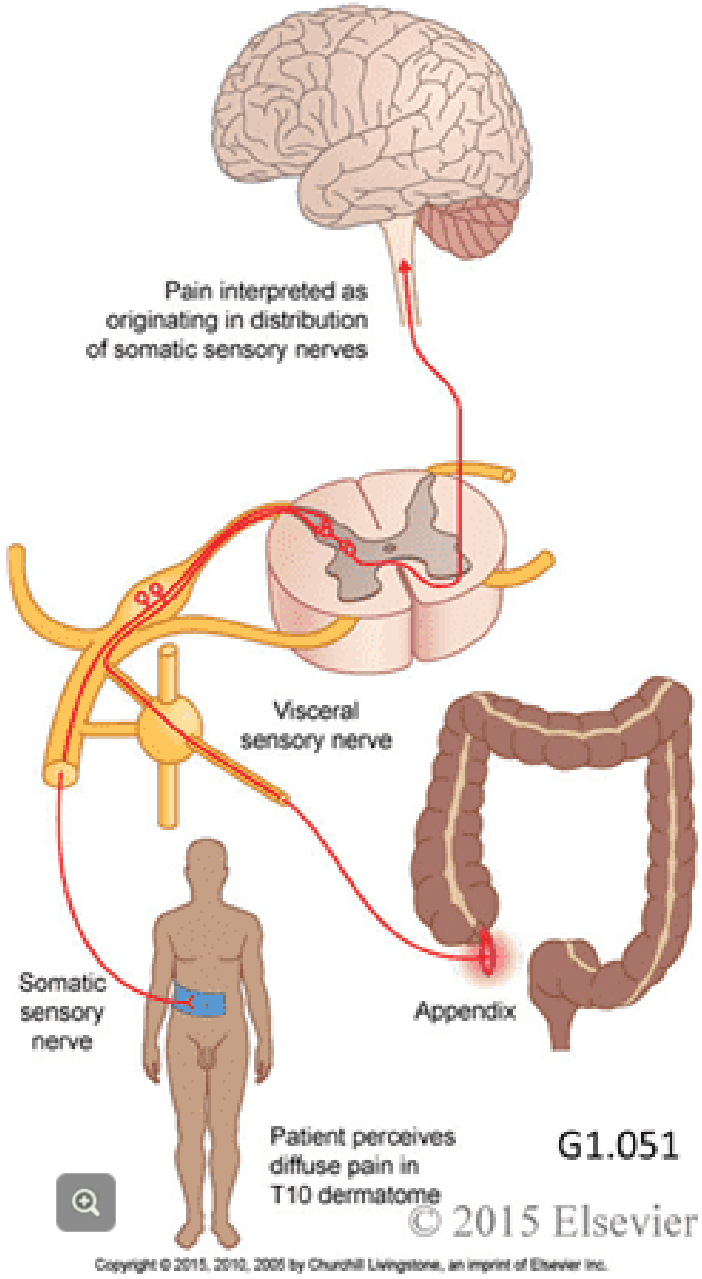


Sensory fibres are a component of all autonomic nerves: the vagi, the pelvic splanchnic nerves and the sympathetic splanchnic nerves. These fibres carry information to the CNS regarding the viscera they serve.

In general, sensory fibres in the **parasympathetic nerves** carry **homeostatic information**, including that needed to **coordinate reflexive visceral activities**.

In general, sensory fibres in **sympathetic nerves** carry **nociceptive impulses**. Thus, nociceptive signals from a given viscus are conveyed back to the **spinal segments that gives rise to its sympathetic motor input**.

For example, sympathetic motor innervation of the **midgut** arises from roughly the **T_{10} spinal level**. Nociceptive impulses due to an inflamed appendix, for example, is received in the spinal cord at this same level, T_{10}. **The pain is referred to the body wall in the dermatome corresponding to this spinal level**, and the patient experiences visceral-type pain in the region of the umbilicus, which is the level of the **T_{10} dermatome**.



The GI tract and its associated organs develop from a midline embryonic gut tube that is **bilaterally innervated** by the sympathetic nervous system. Therefore, nociceptive signals from the GI tract are **typically referred to the midline**.

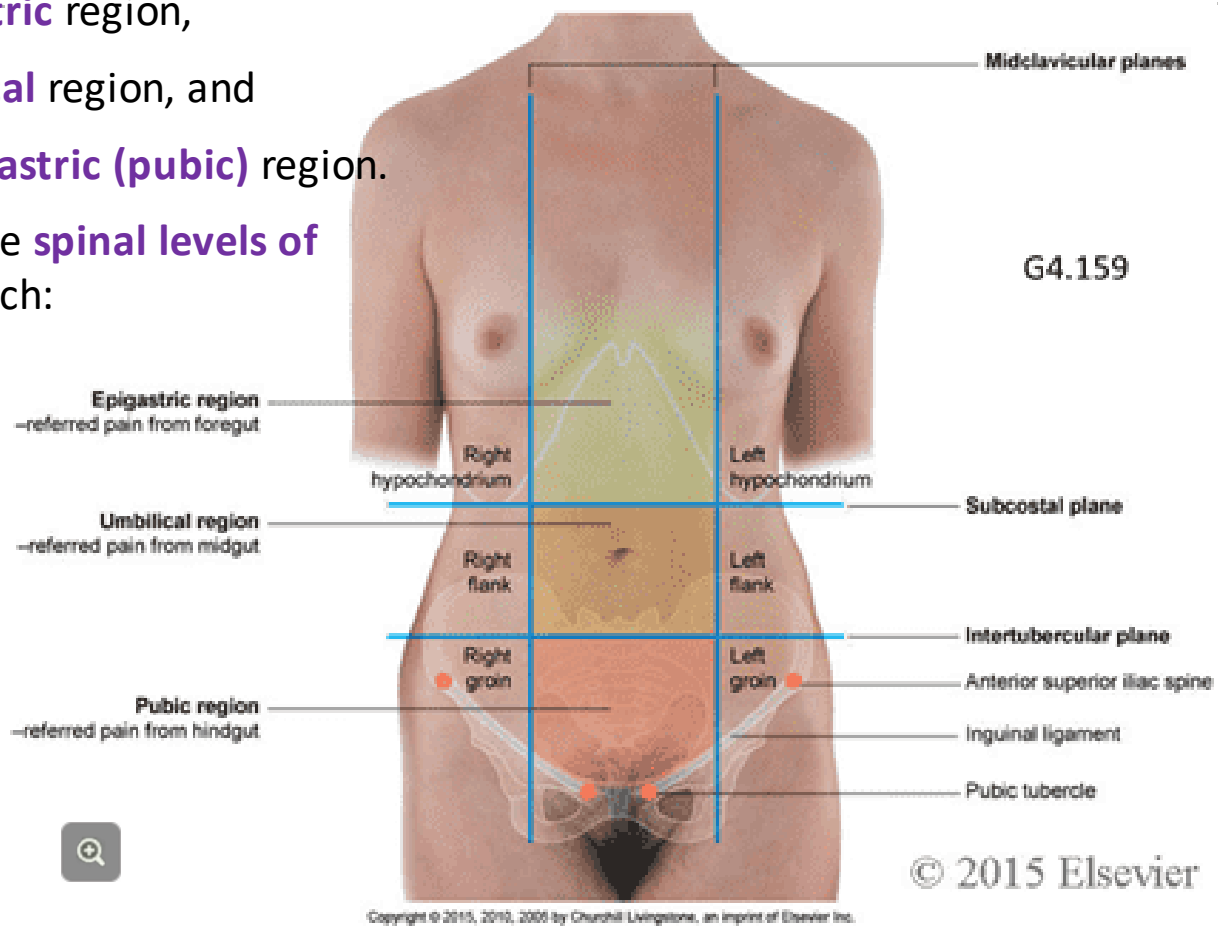
Pain due to irritation of:

1. **foregut** structures refers to the **epigastric** region,
2. **midgut** structures refers to the **umbilical** region, and
3. **hindgut** structures refers to the **hypogastric (pubic)** region.

These **dermatomal levels** correspond to the **spinal levels of origin** of the sympathetic innervation of each:

1. the **foregut** from **T5 - T9**,
2. the **midgut** from **T10 & T11**, and
3. the **hindgut** from **T12 and below**.

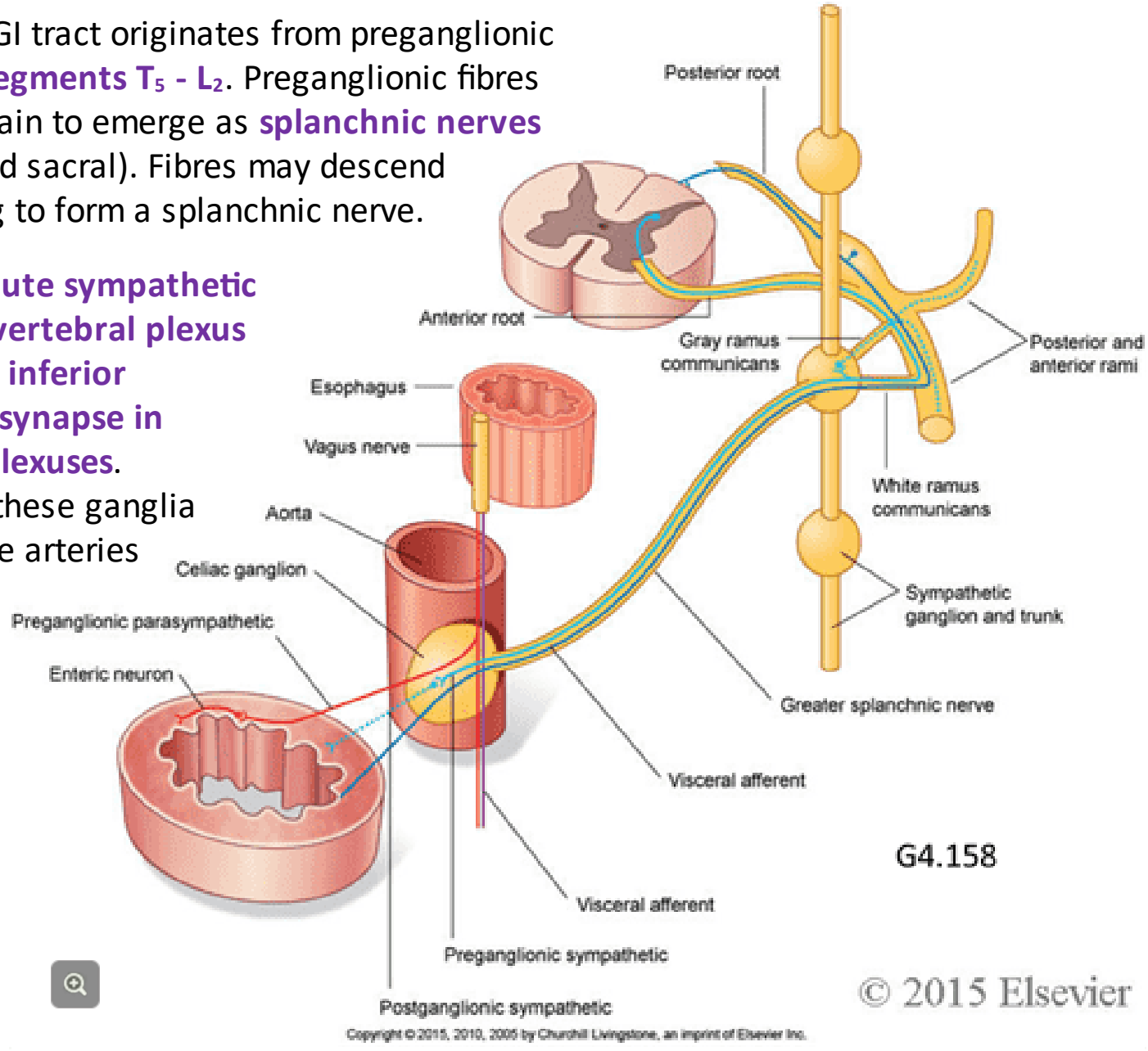
If the parietal peritoneum lining the internal surface of the body wall is irritated by an inflamed viscus, for example, nerves of the body wall report this pain which is somatic in nature – sharp and well-localized.



Sympathetic innervation of the GI tract originates from preganglionic **neuronal cell bodies in spinal segments T_5 - L_2**. Preganglionic fibres pass through the sympathetic chain to emerge as **splanchnic nerves** (greater, lesser, least, lumbar and sacral). Fibres may descend within the chain before emerging to form a splanchnic nerve.

These splanchnic nerves **contribute sympathetic preganglionic fibres to the prevertebral plexus and its pelvic continuation, the inferior hypogastric plexus**. Their fibres **synapse in ganglia associated with these plexuses**. Postganglionic fibres arise from these ganglia and join plexuses surrounding the arteries that supply their target organs.

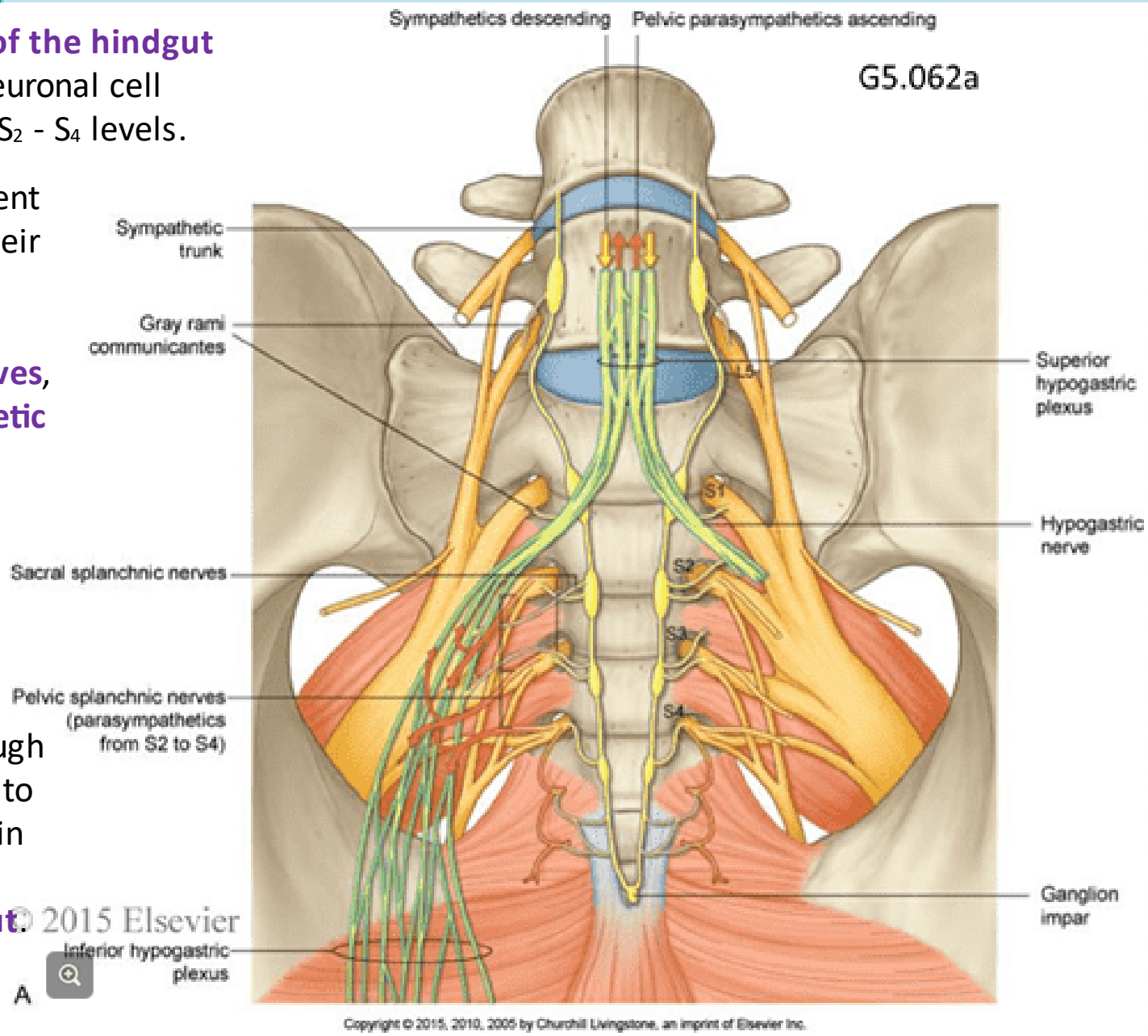
The **vagus nerves** contribute **parasympathetic preganglionic fibres to the prevertebral plexus**. Its fibres join the extensions of these plexuses along blood vessels to their target organs of the **foregut and midgut**.



Parasympathetic innervation of the hindgut originates with preganglionic neuronal cell bodies in the spinal cord at the S_2 - S_4 levels.

Their axons travel as a component of the S_2-S_4 spinal nerves and their ventral rami. In the pelvis, they branch from the ventral rami to form the **pelvic splanchnic nerves**, which contribute **parasympathetic preganglionic fibres to the inferior hypogastric plexus**.

From the inferior hypogastric plexus, some of these parasympathetic preganglionic fibres are distributed to **pelvic structures**. Others ascend through the superior hypogastric plexus to the aortic plexus, where they join its extension along the inferior mesenteric artery to the **hindgut**.



11.1 Dissection of the Foregut

What you'll need:

SPECIMENS

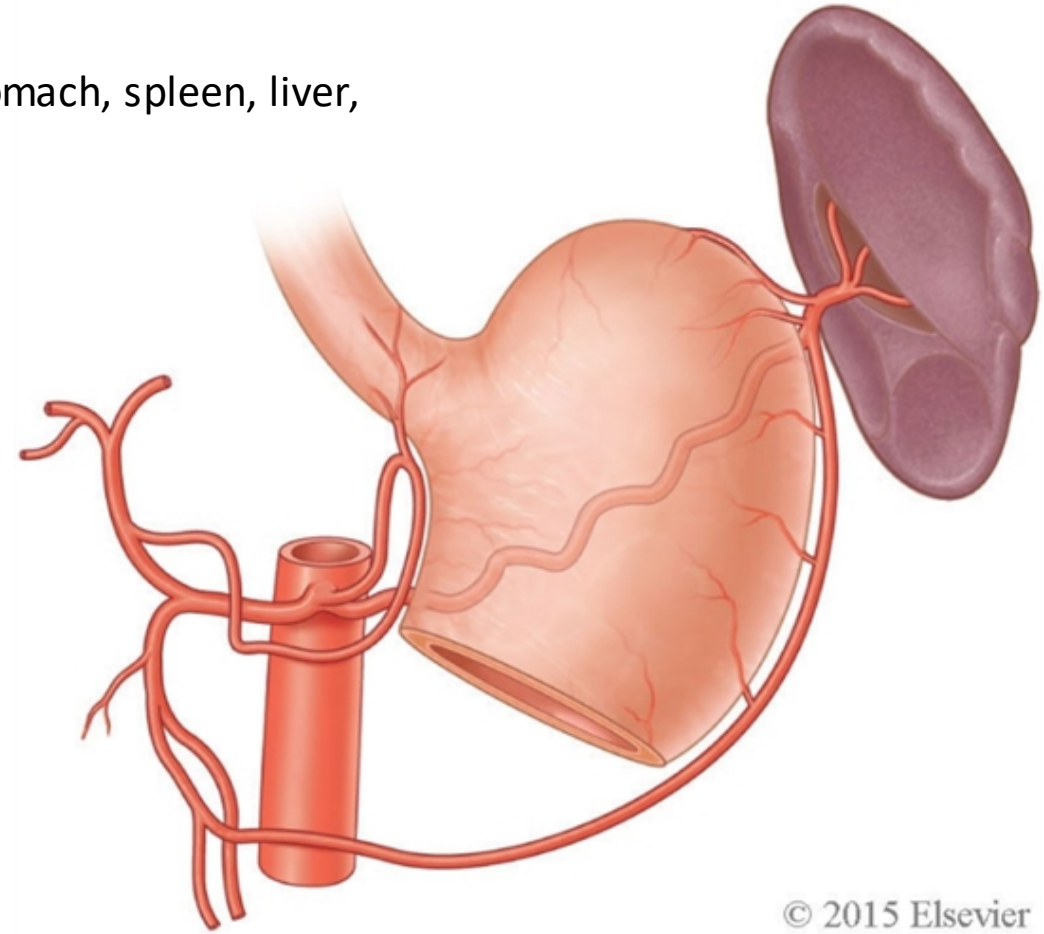
- Cadavers 1 & 2
- Abdominal Organs Teaching Bin

INSTRUCTIONS

You will now pick up where you left off at the end of lab 10 and complete the foregut dissection. The following slides are repeated from Exercise 10.3. Review what you've done so far and then carry on. It should take you the full six hours to complete this dissection properly. Check in with your TA regularly to ensure you are revealing all structures adequately.

When you have completed this dissection, you will be able to identify and describe the:

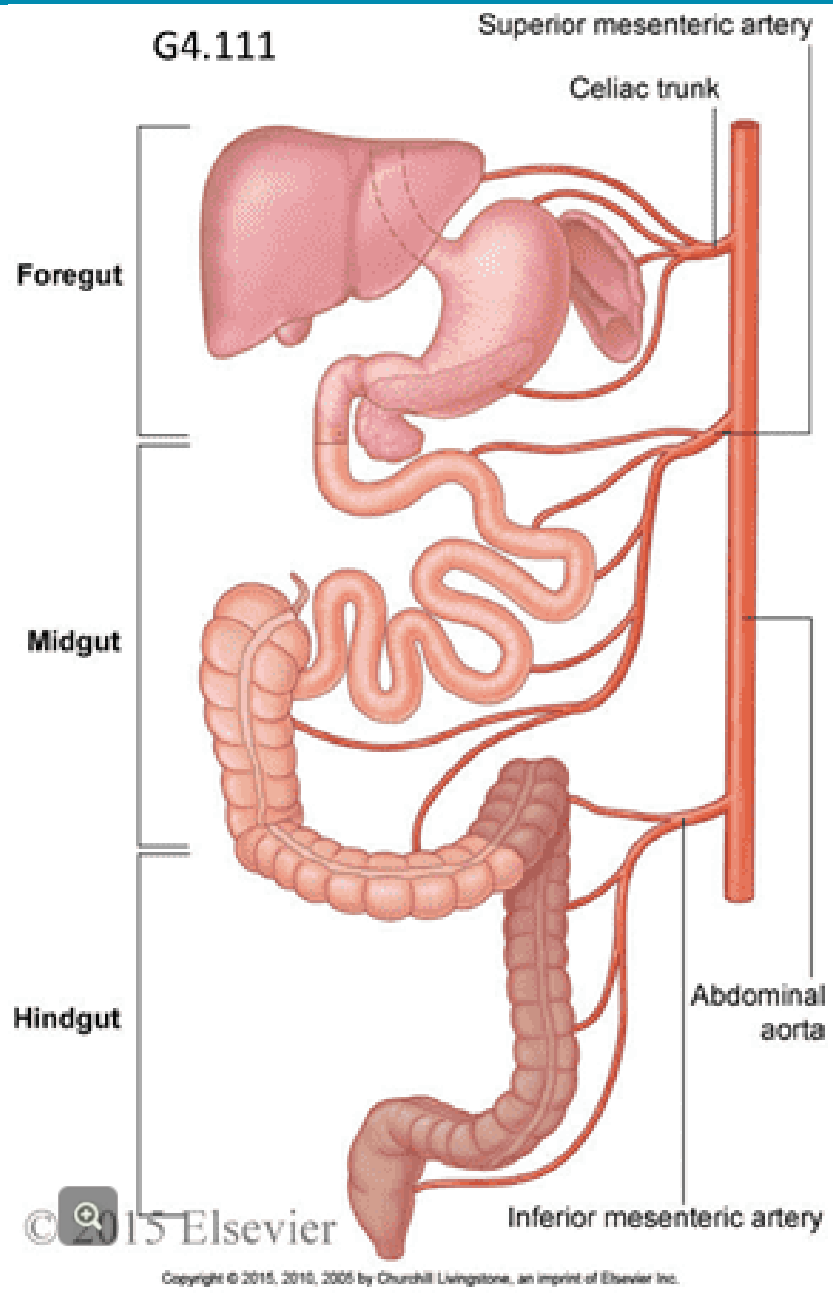
- gross features of the stomach.
- hepatoduodenal and hepatogastric ligaments and the structures contained therein.
- celiac trunk and its branches that supply the stomach, spleen, liver, gallbladder, duodenum and pancreas.
- hepatic portal vein and its tributaries.

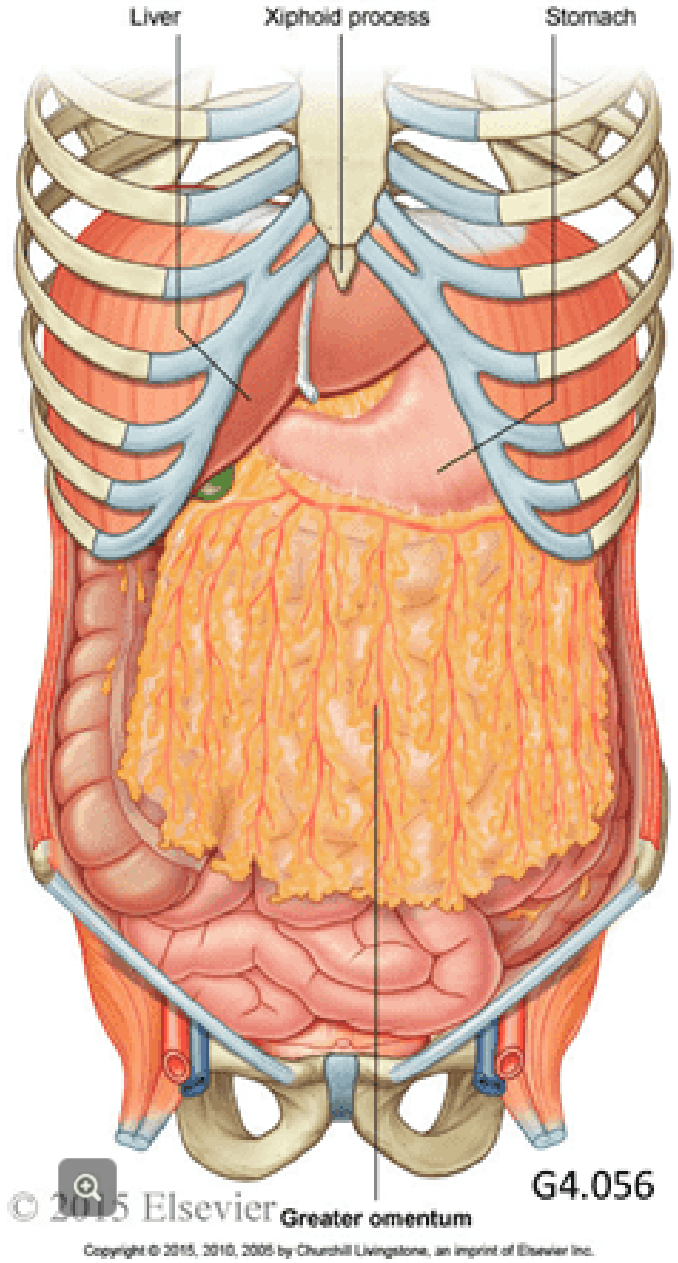


The digestive tract is a single (albeit convoluted) tube that has **three subdivisions: the foregut, midgut and hindgut**. It receives its blood supply from **three, unpaired, visceral branches of the abdominal aorta**. The **foregut** receives its blood supply from the **celiac trunk**, the **midgut** from the **superior mesenteric artery** and the **hindgut** from the **inferior mesenteric artery**.

These vessels arise from the aorta in the posterior body wall. In order for their branches to gain access to intraperitoneal organs, they must pass through **mesenteries** or **ligaments**, the latter being structures analogous to mesenteries, but smaller. Like mesenteries, ligaments **consist of two layers of serous membrane with loose CT, adipose, Ns, BVs and Ls sandwiched between them**.

The focus of this dissection is the foregut. You will dissect the branches of the celiac trunk that supply the liver, gallbladder, stomach, spleen, the proximal duodenum and a portion of the pancreas.





TASK

BEFORE DISSECTING,

remove the lungs and heart from your cadaver, wrap them in moist cloths, and set them aside for the duration of the session. Doing so will allow you to retract the costal margin superiorly to improve your access to the foregut. **Replace these organs when you clean up at the end of the session.**

Try retracting the costal margin and liver superiorly. If this proves to be difficult, use bone snippers or a small saw from the tool box to **cut the costal margin in the midaxial line, bilaterally**. This will create a "hinge" that will permit greater elevation of the costal margin and liver.

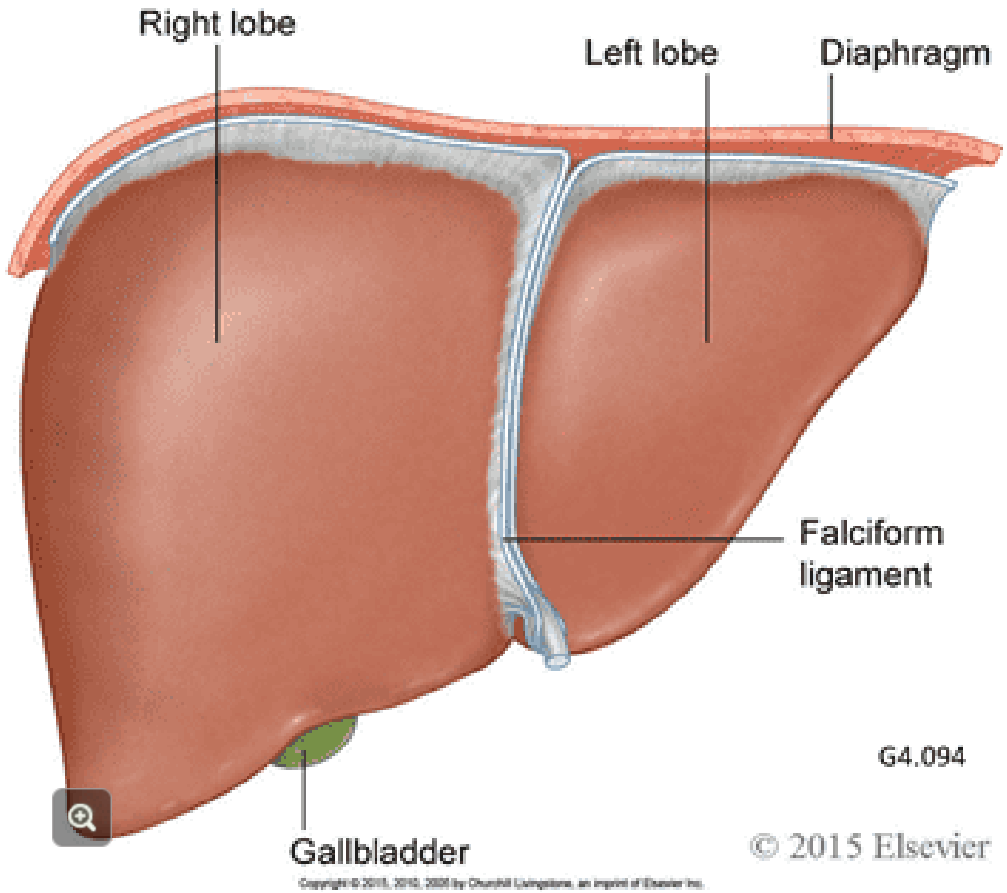
Now, place the greater omentum in its correct anatomical position, and get your bearings by identifying the structures that comprise the foregut.

The liver produces **bile**, which is transported to the duodenum by a series of ducts. **Bile emulsifies dietary fats**, thus **facilitating their enzymatic digestion by pancreatic lipases**. The liver produces bile constantly. The **gall bladder stores and concentrates bile** until the contents of the duodenum necessitates its delivery via the bile duct system.

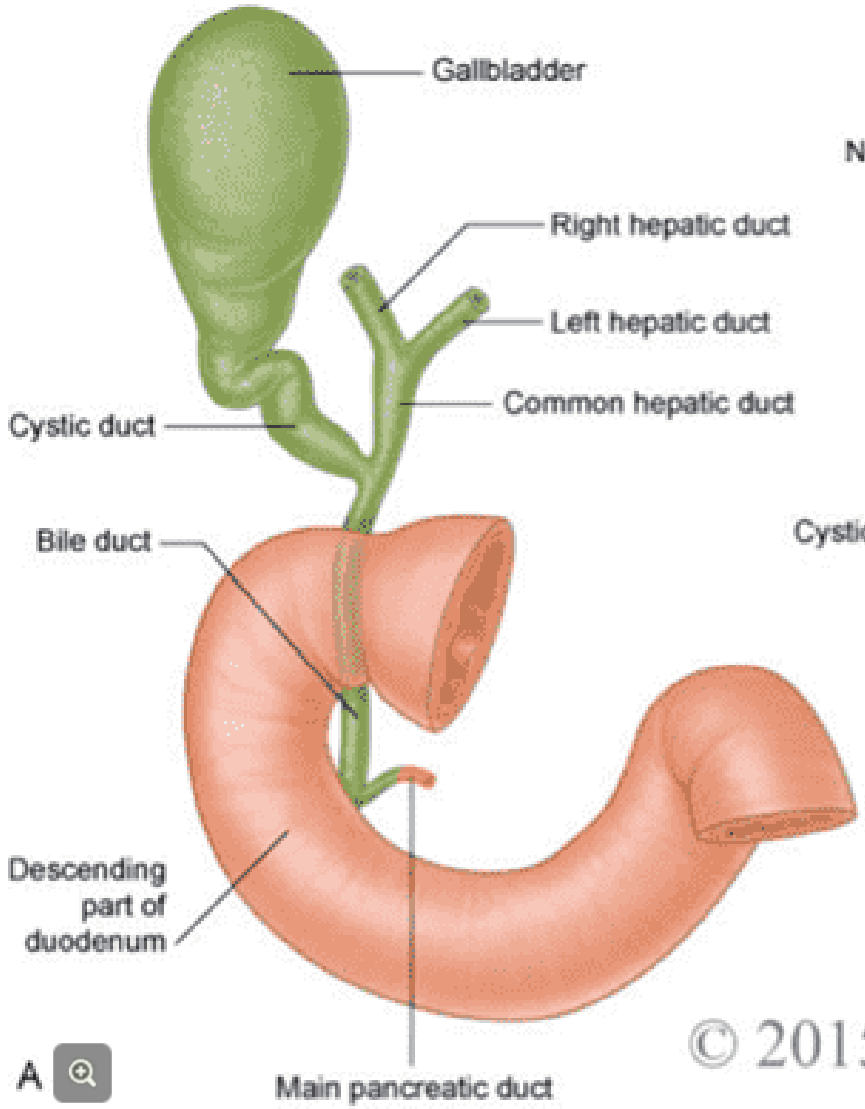
TASK

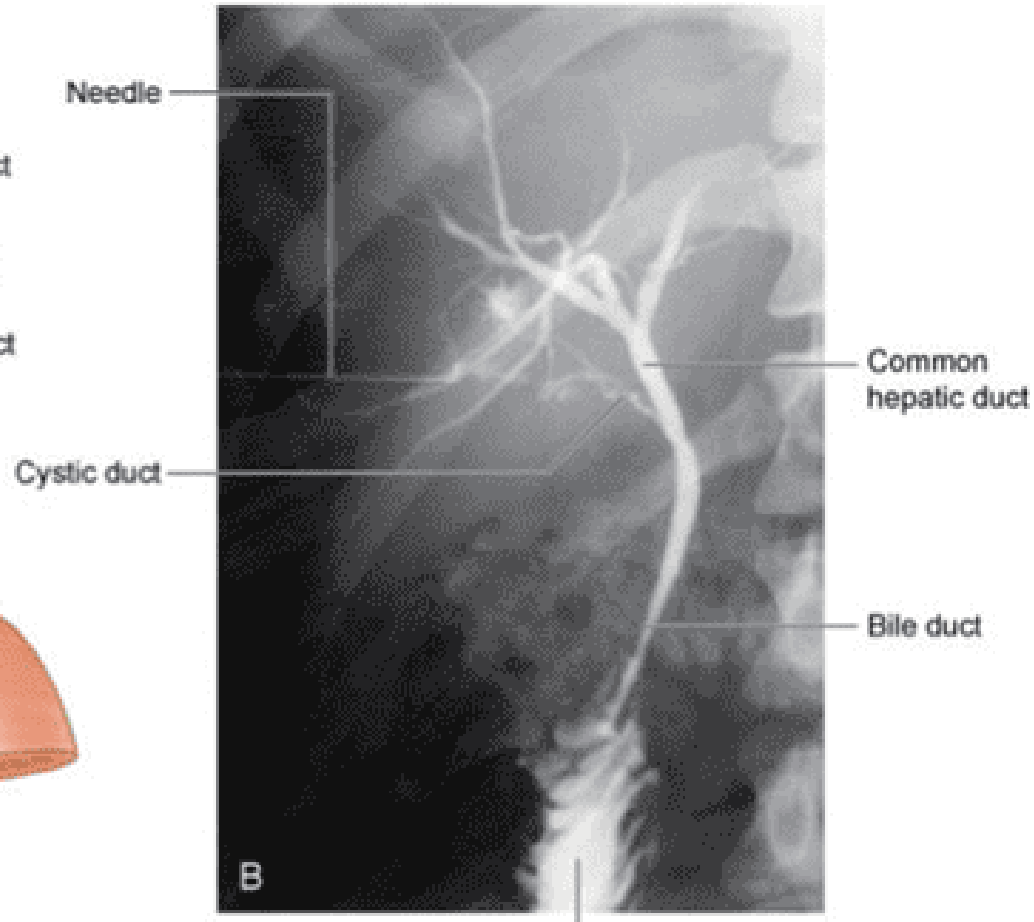
START with the diaphragmatic surface

of the liver. Identify its **right and left lobe**, the **falciform ligament** that separates them, and the **inferior border of the liver**. Notice the **gall bladder** (if it is not present, it was surgically removed via a **cholecystectomy**), which extends beyond the inferior border of the liver at the level of the **ninth costal cartilage**.



The Bile Duct System



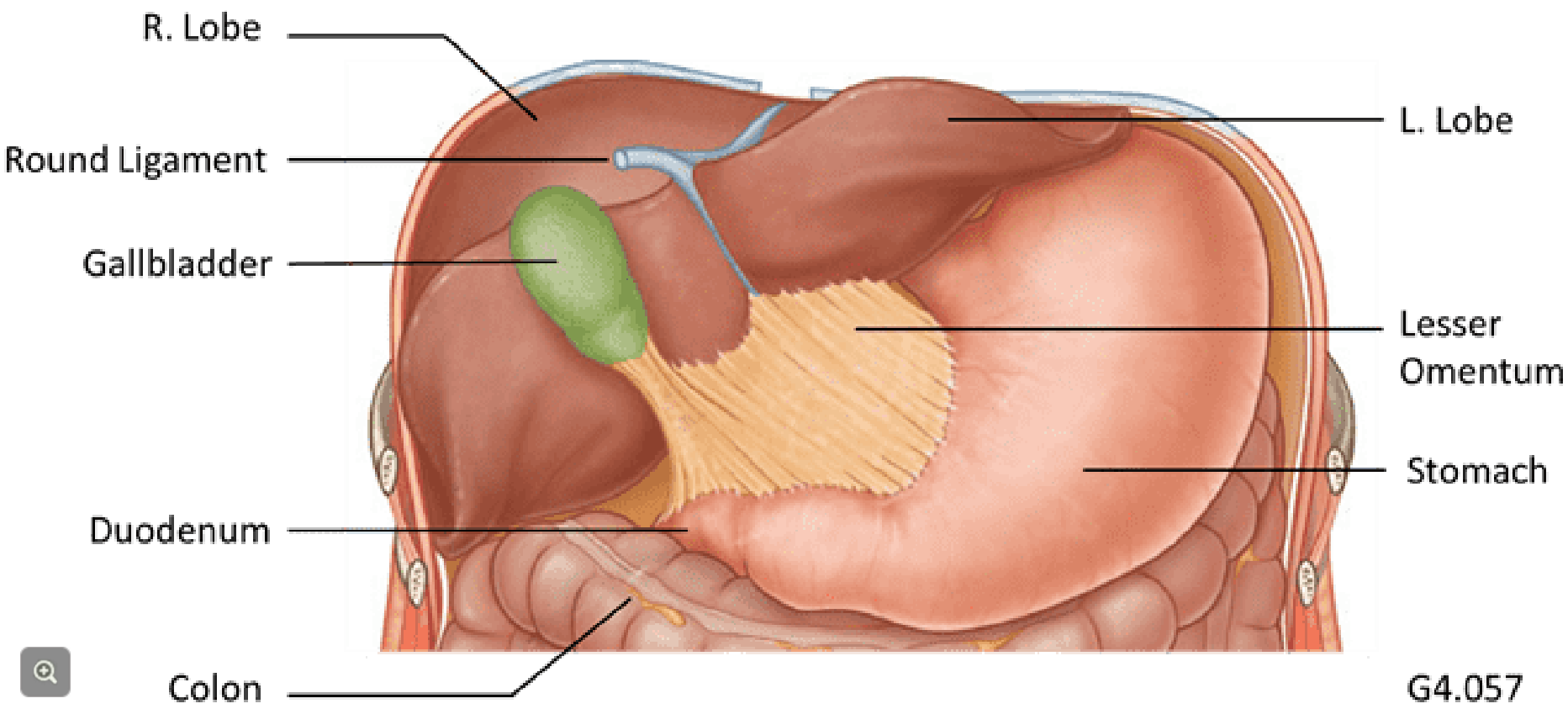


G4.102

TASK

ONE MEMBER of your group should raise the inferior border of the liver,

thus exposing its visceral surface. There, identify the hilus of the liver, the **porta hepatis**, through which vessels, ducts, lymphatics, and nerves enter the liver. Take note of the **structures in contact with the visceral surface of the liver**: the **gall bladder** (if present), the **stomach**, the **duodenum**, the **colon**, and through the parietal peritoneum lining the posterior wall of the hepatorenal recess, the **right kidney** and **right suprarenal gland**.



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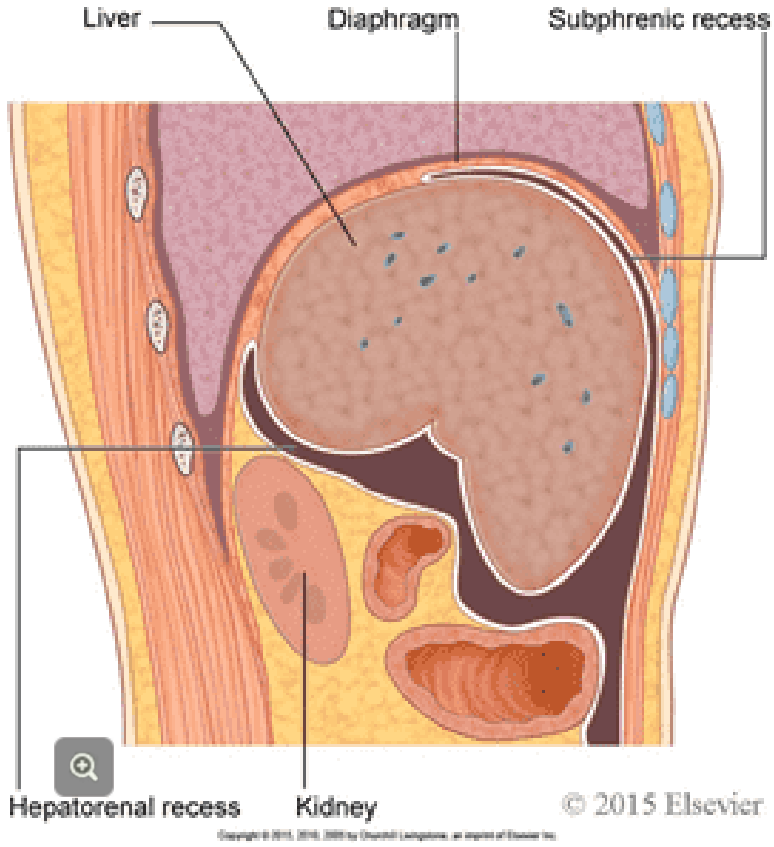


G4.093

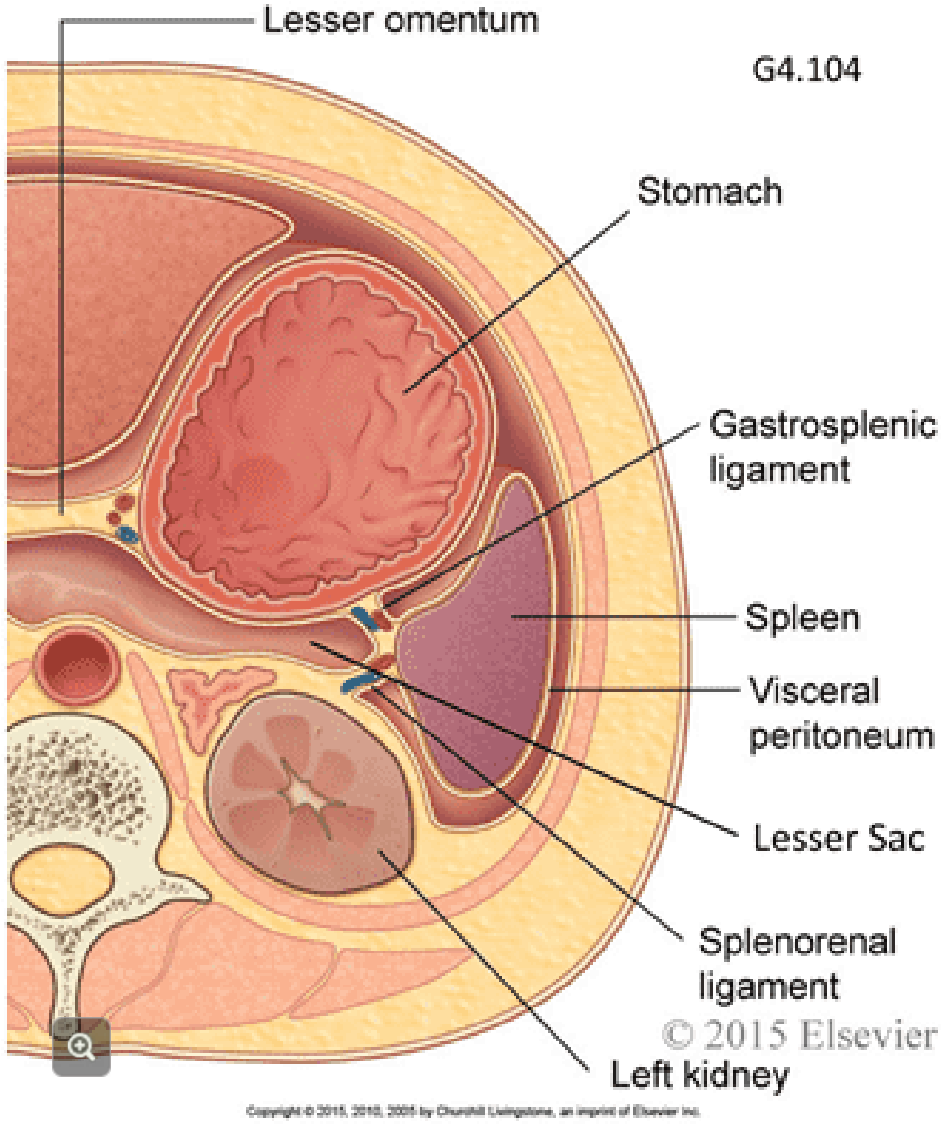
TASK

FROM the cadaver's right side, and with your right hand,

reach around to the left of the stomach and wrap your hand around the spleen. The tip of your thumb will be touching the gastrosplenic ligament and the tips of your fingers will be touching the splenorenal ligament.

These ligaments contain **blood vessels** that arise from the **celiac trunk** to supply the **spleen** and portions of the **stomach**. Remember, the celiac trunk is retroperitoneal. Its branch, the **splenic artery**, accesses the spleen, an intraperitoneal organ, by passing through the **splenorenal ligament**. Look at the illustration and **notice that the name of the ligament is easy to remember because it describes its points of attachment**. Branches of the splenic artery access the greater curvature of the stomach by passing through the **gastrosplenic ligament**. Again, the ligament is named according to its points of attachment.

Notice again, from the illustration that these ligaments form the left border of the lesser sac.



Turn your attention to the stomach and its gross anatomical features.

TASK

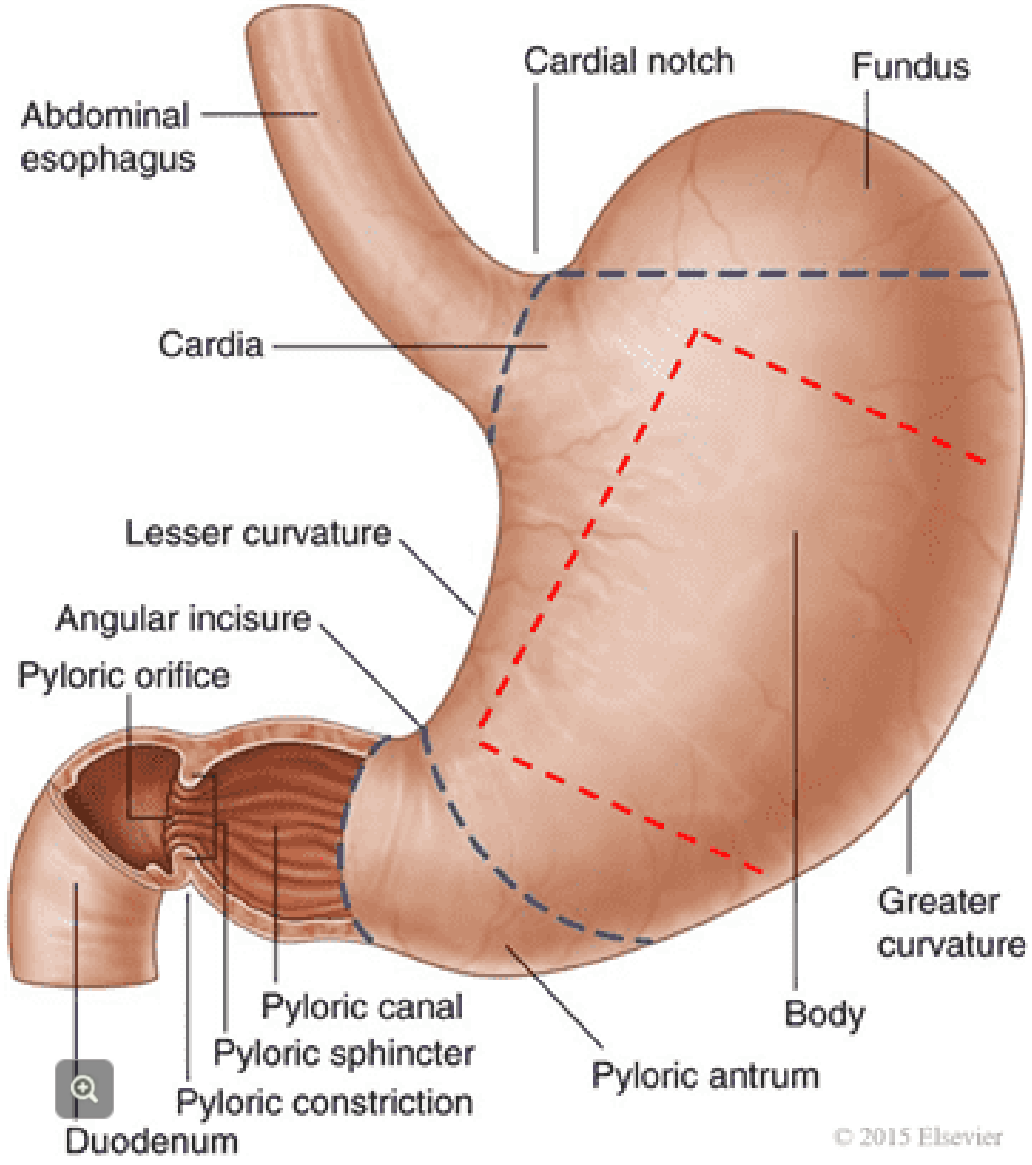
IDENTIFY the

- body
- greater curvature
- lesser curvature
- cardia
- cardial notch
- fundus
- pylorus (inc. pyloric antrum, canal)
- pyloric sphincter

TASK

CUT a flap

in the anterior wall of the stomach, as illustrated by the red dotted lines in the figure. If there is fluid in the stomach lumen, use a rag to absorb it. On the internal surface of the stomach, identify the rugae, longitudinal folds in the stomach wall that flatten out as the stomach fills, increasing its capacity.

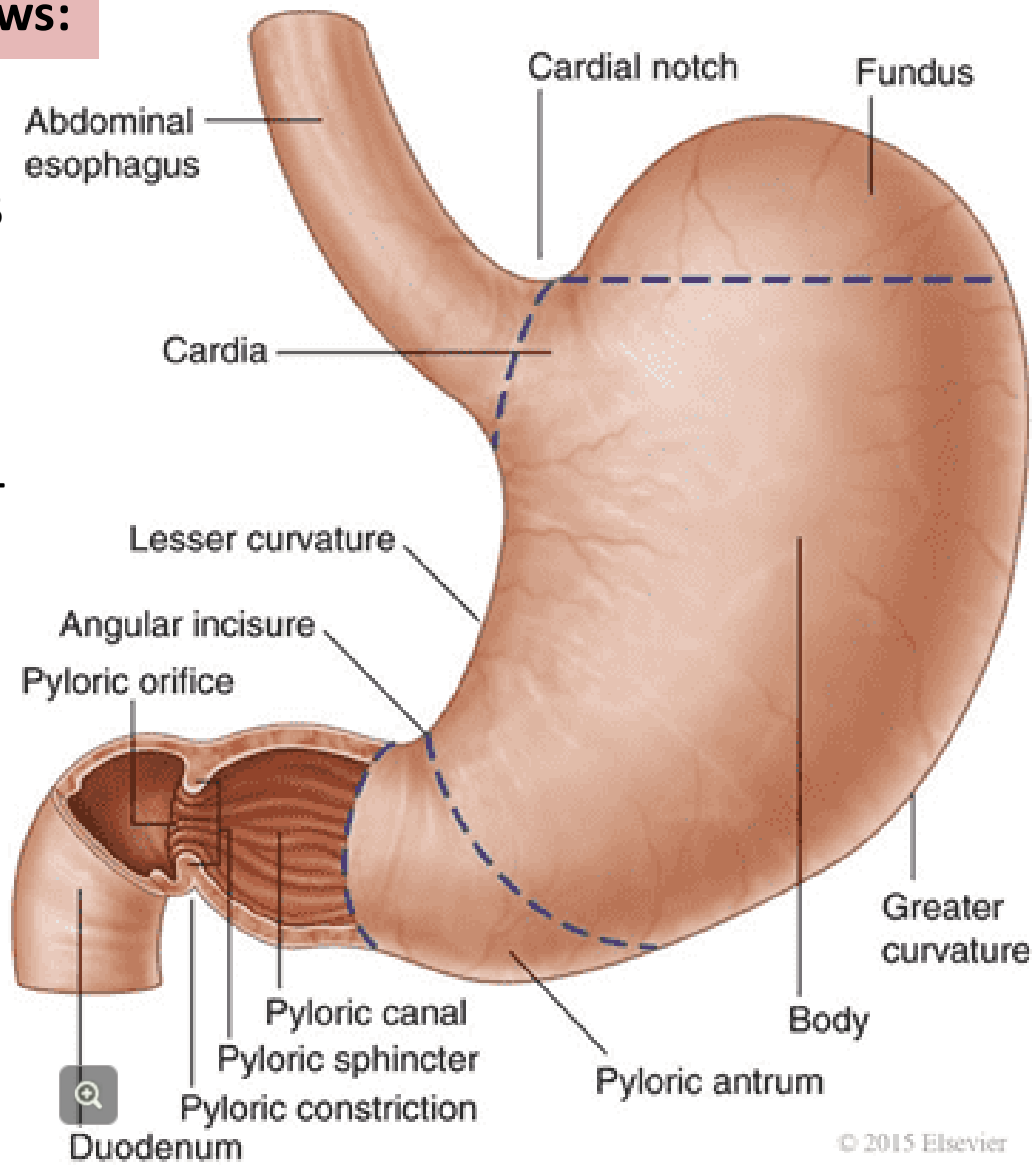


TASK

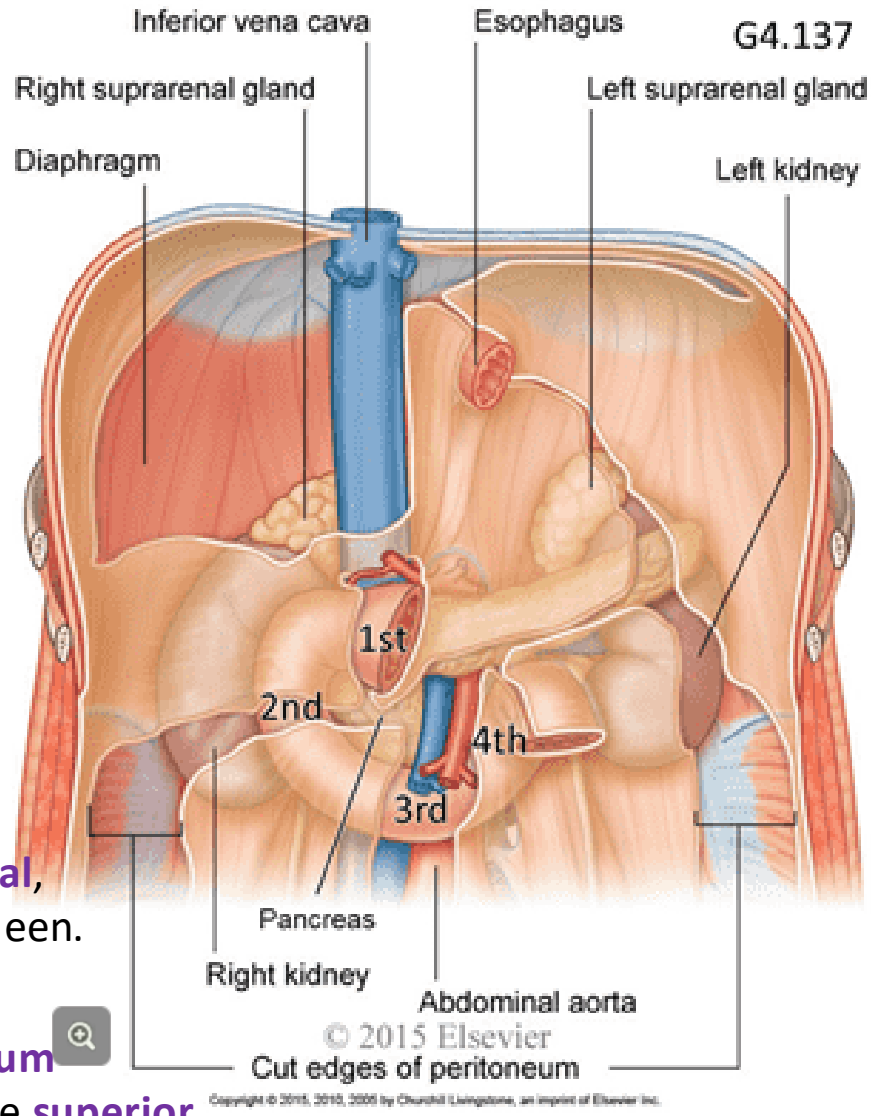
IDENTIFY the pyloric sphincter as follows:

Pinch the thickness of the stomach wall between your index finger and thumb. Note that your thumb and finger are, perhaps 0.5 cm apart, which gives you some idea of the thickness of the wall of this muscular sack. Now feel the thickness of the pyloric sphincter by pinching it between your thumb and finger. You will find that your thumb and finger are now 2.5 - 3 cm apart! This is a very strong sphincter.

The pyloric sphincter controls the passage of chyme (partially digested food) from the stomach into the duodenum. Anatomically, it consists of a thickening of the circular layer of smooth muscle within the wall of the gut at the gastroduodenal junction.



The dividing line between the foregut and midgut passes through the duodenum and pancreas.
The duodenum is subdivided into 1st (superior), 2nd (descending), 3rd (transverse) and 4th (ascending) parts.
The proximal 2 cm of the 1st part is intraperitoneal and therefore mobile. This is the portion that is attached to the **hepatoduodenal ligament**. **The remainder of the duodenum is secondarily retroperitoneal.**



TASK

EXPLORE the intraperitoneal portion of the duodenum. Insert your index finger though the epiploic foramen and observe that the hepatoduodenal ligament is anterior to your finger and the duodenum is inferior to your finger as it passes into the posterior body wall where it becomes secondarily retroperitoneal and therefore fixed.

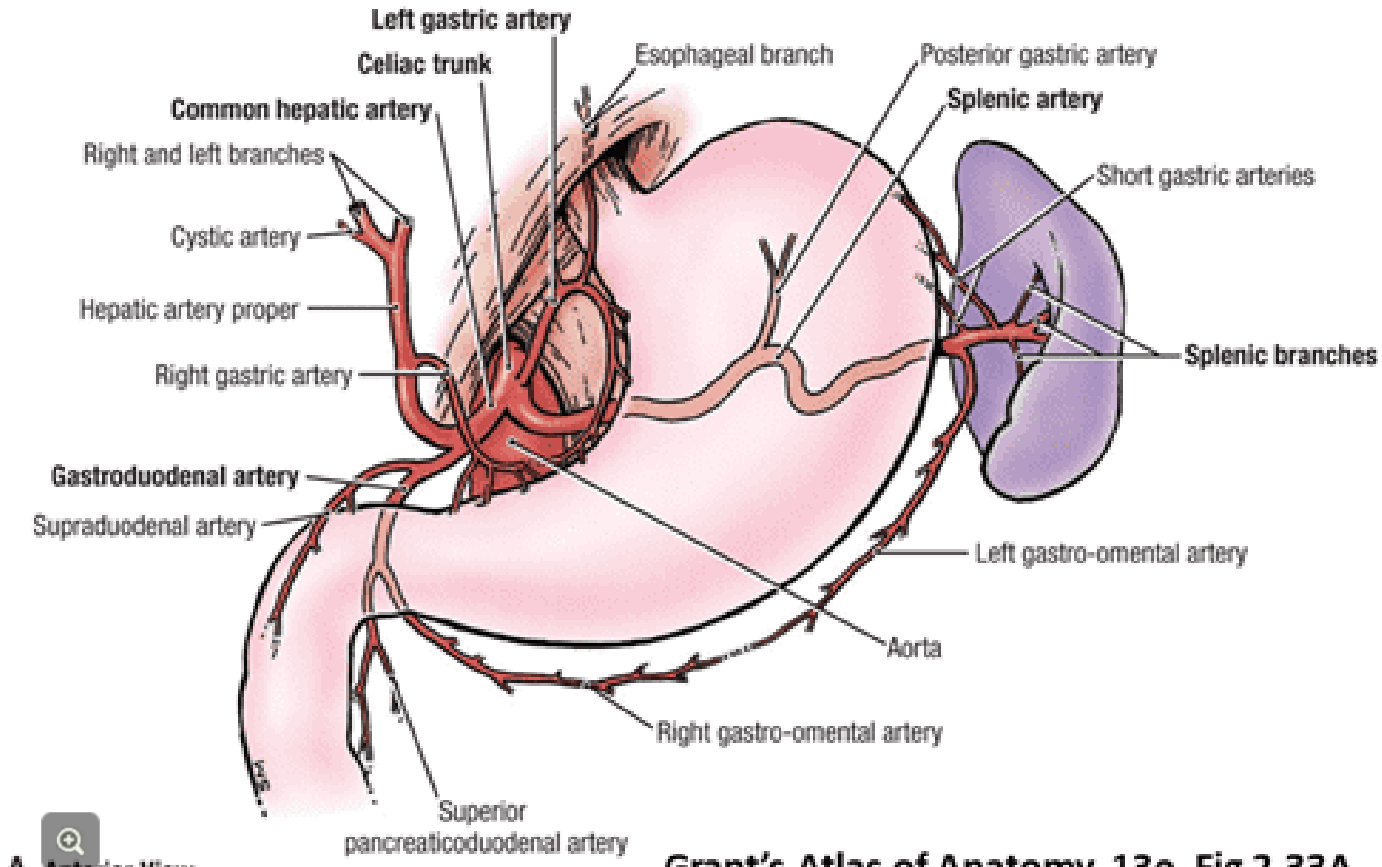
As illustrated, the **pancreas**, also **secondarily retroperitoneal**, lies in the curve of the duodenum and extends toward the spleen.

The **proximal duodenum** and **portions of the pancreas** are supplied by branches of the **celiac trunk**. The **distal duodenum** and **portions of the pancreas** are supplied by branches of the **superior mesenteric artery**. The details will come later in the dissection.

The focus of this dissection is the foregut. You will learn the anatomy of the foregut using its blood supply to guide the progress of your dissection.

Thus, start by learning the major branches of the celiac trunk.

The branches of the celiac trunk are named for their area of distribution, which helps you to remember this important information. The three branches of the celiac trunk are the **common hepatic artery**, **the left gastric artery** and **the splenic artery**.



A. Anterior View

Grant's Atlas of Anatomy, 13e, Fig 2.33A

The Common Hepatic Artery

The **common hepatic artery** arises from the celiac trunk. It runs to the right, retroperitoneally, toward the duodenum and bifurcates into the **gastroduodenal artery** and the **hepatic artery proper**.

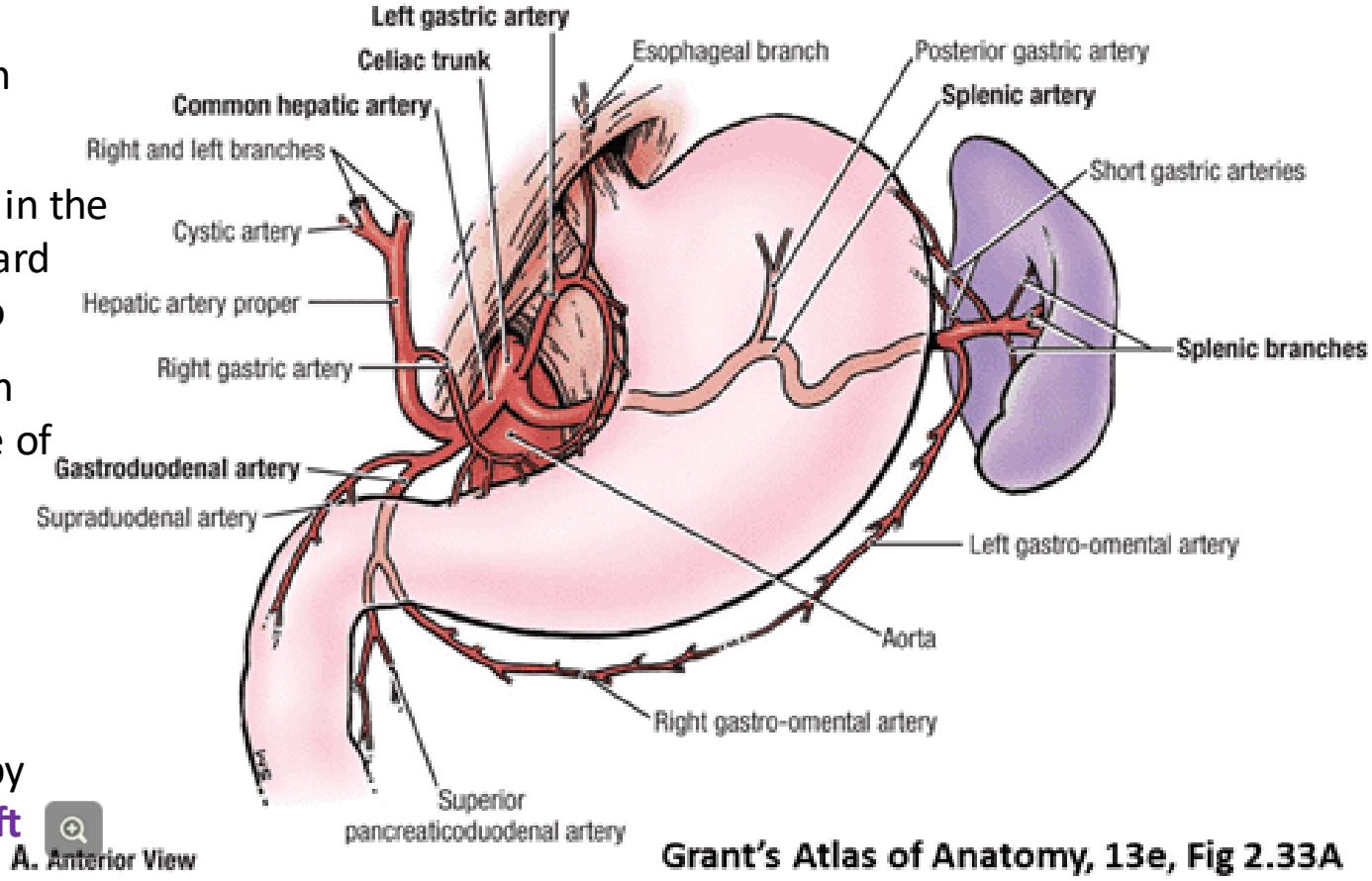
The gastroduodenal artery remains retroperitoneal and **passes posterior to the 1st part of the duodenum**. It continues as the **right gastro-omental (gastro-epiploic) artery**. The right gastro-omental (gastro-epiploic) artery runs along the greater curvature of the stomach within the greater omentum.

The **hepatic artery proper** runs in the **hepatoduodenal ligament** toward the porta hepatis. It gives rise to

i) **the right gastric artery**, which descends to the lesser curvature of the stomach within the lesser omentum, and

ii) the **cystic artery**, which supplies the gall bladder.

The hepatic artery proper ends by bifurcating into the **right and left hepatic arteries**.



Grant's Atlas of Anatomy, 13e, Fig 2.33A

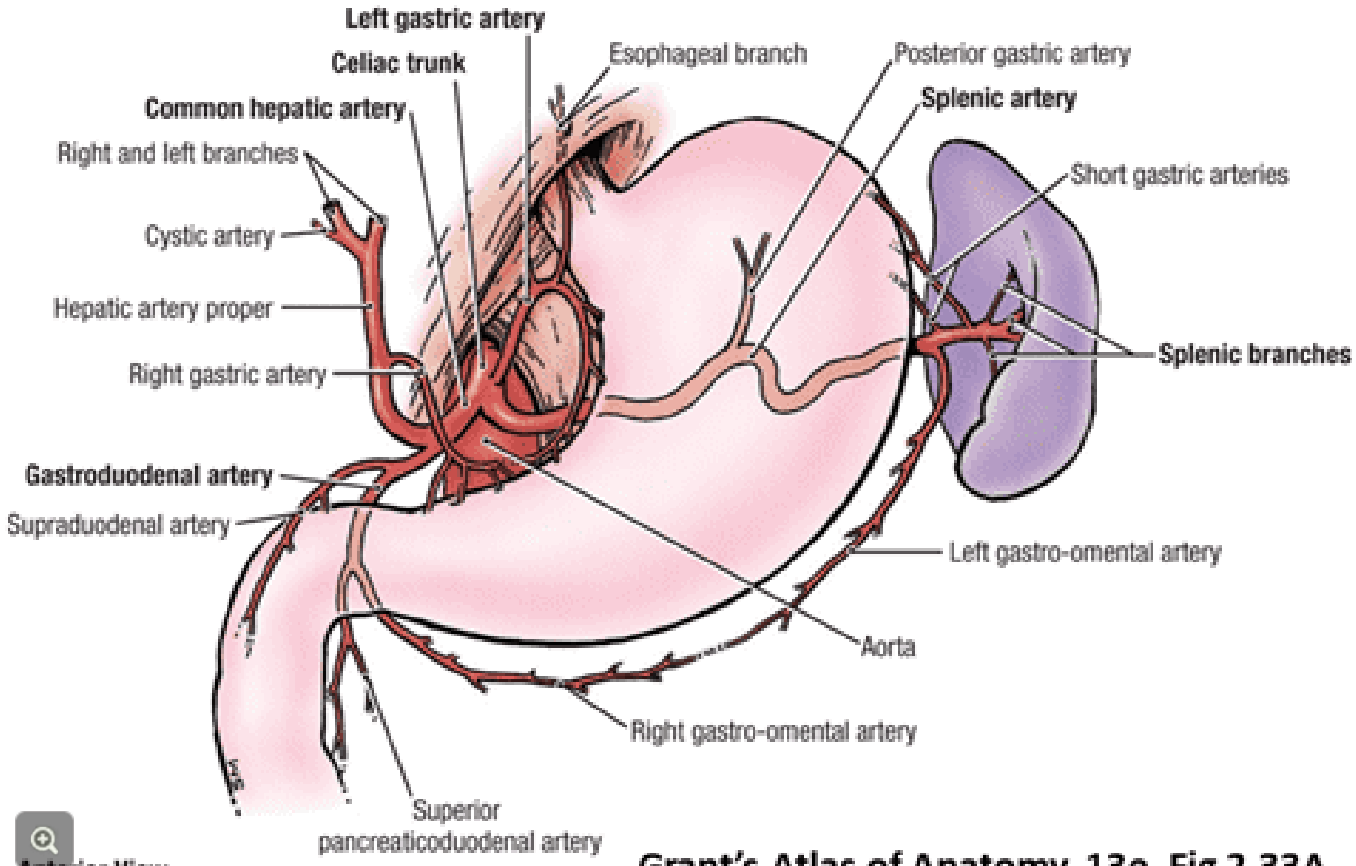
The Left Gastric Artery

The **left gastric artery** arises from the celiac trunk, and is therefore, initially, retroperitoneal.

It ascends to the left to the point where the esophagus emerges through the diaphragm to become intraperitoneal. It gives an **esophageal branch** which ascends to supply the retroperitoneal portion of the distal 1/3 of the esophagus.

The **left gastric artery** then accompanies the intraperitoneal terminus of the esophagus to the **lesser curvature of the stomach**.

It runs within the lesser omentum and forms an **arterial anastomosis with the right gastric artery along the lesser curvature of the stomach**.



A. Anterior View

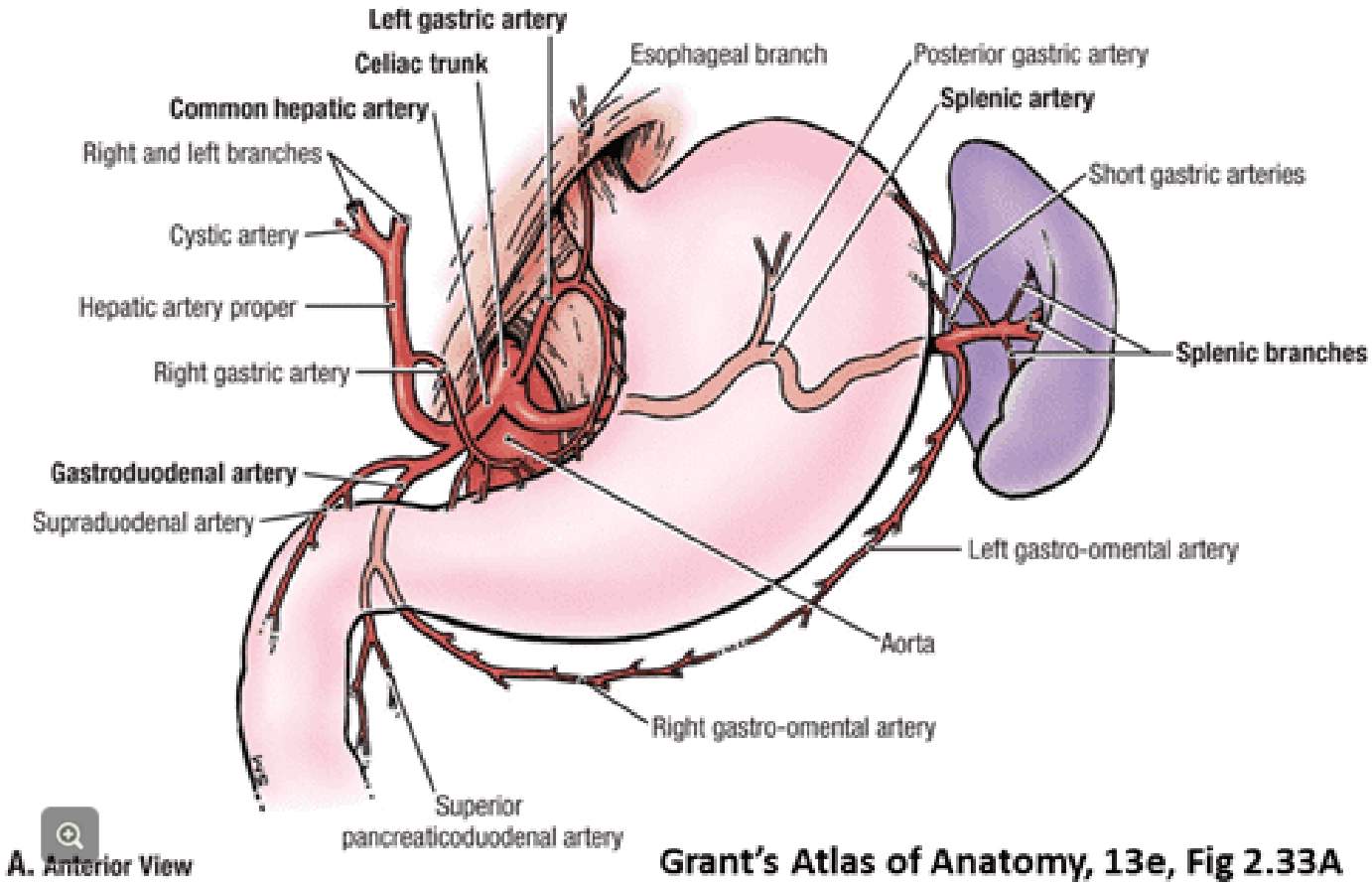
Grant's Atlas of Anatomy, 13e, Fig 2.33A

The Splenic Artery

The **splenic artery** arises from the celiac trunk. It runs to the left, retroperitoneally, toward the spleen. It **passes through the splenorenal ligament to access the hilum of the spleen**. Before entering the hilum of the spleen, it gives rise to the following branches that pass through the **gastrosplenic ligament** to access the greater curvature of the stomach.

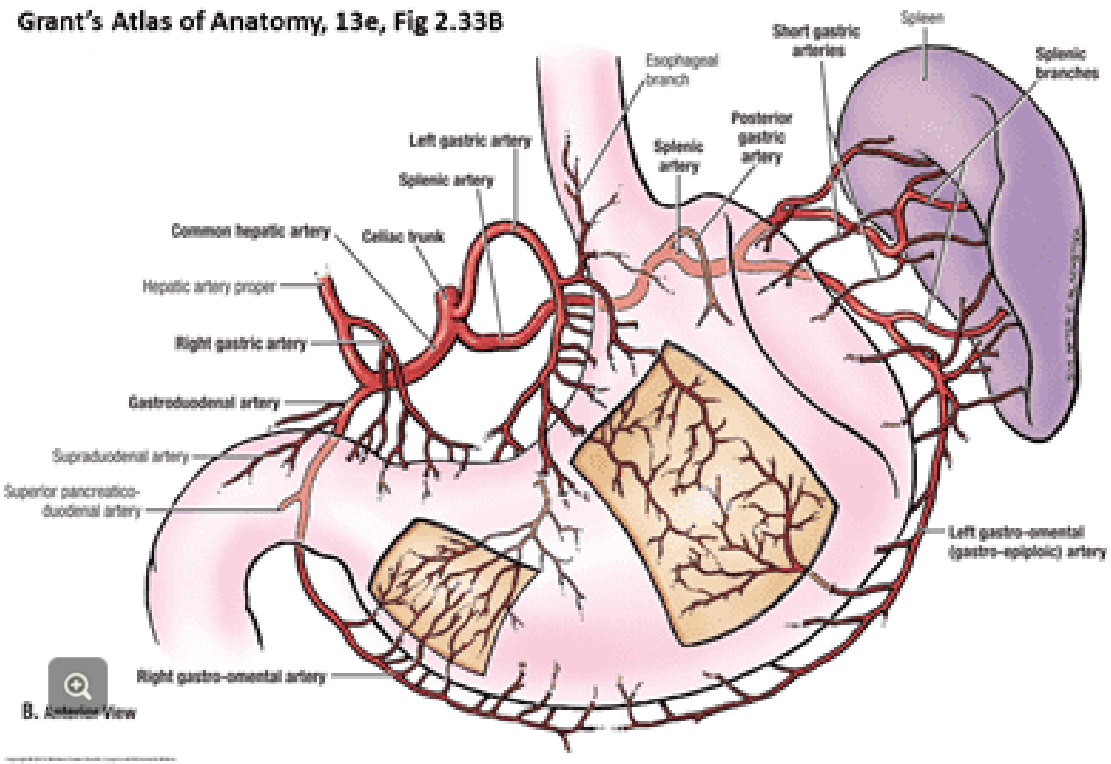
i) the **short gastric arteries**, which ascend along the greater curvature of the stomach, within the greater omentum, to its fundus, and

ii) the left g**astro-omental (gastro-epiploic) artery**, which descends along the greater curvature of the stomach, in the greater omentum. The latter artery **anastomoses with the right gastro-omental (gastro-epiploic) artery within the greater omentum**.



A. Anterior View

Grant's Atlas of Anatomy, 13e, Fig 2.33A



The vessels supplying the stomach run along its **lesser** and **greater curvatures**, within the **lesser** and **greater omenta**, respectively.

Within the lesser omentum are the **left** and **right gastric arteries**, the former branching from the celiac trunk and the latter usually arising from the hepatic artery proper.

Within the greater omentum are the **left** and **right gastro-omental (gastro-epiploic) arteries**, the former branching from the splenic artery and the latter arising as the continuation of the gastroduodenal artery. The **short gastric arteries** arise from the splenic artery and ascend in the greater omentum toward the fundus of the stomach.

From these parent arteries running along the margins of the stomach, vessels arise and run within the visceral peritoneum of the stomach to **anastomose on both its anterior and posterior surfaces**, as illustrated in the accompanying figure.

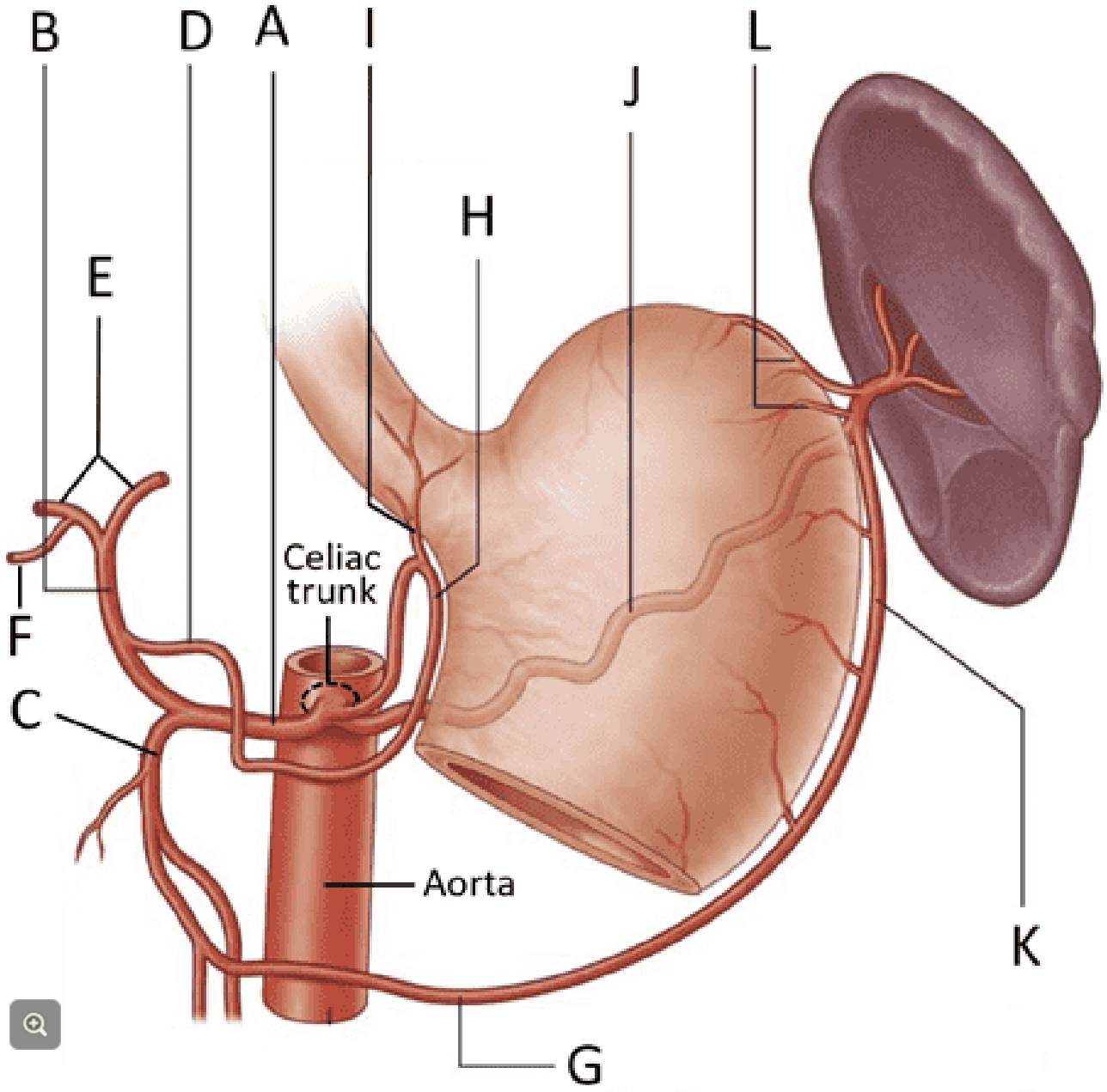
It would be a good idea for one member of your group to draw the vessels described on a white board or chalk board adjacent to your table before embarking on the dissection.

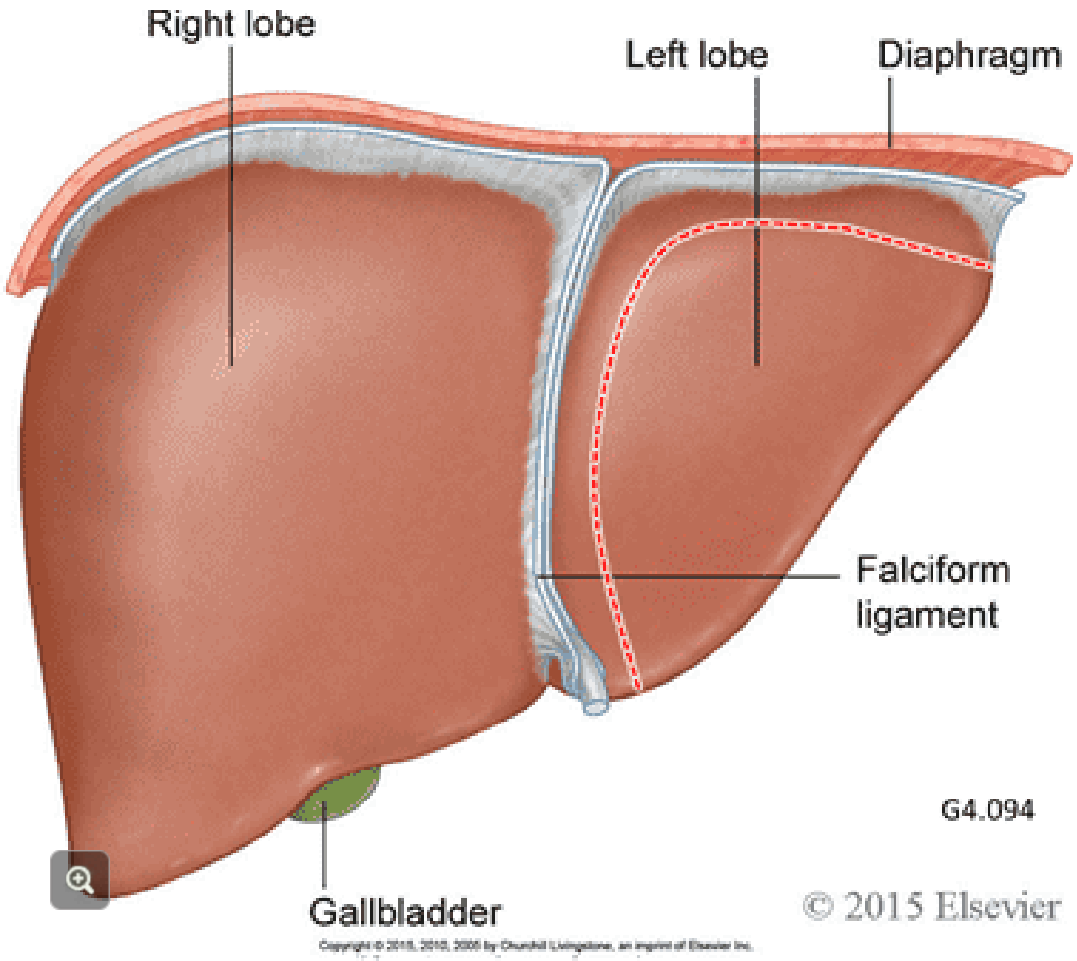
In order to complete a dissection successfully, it is critical to know the anatomy of the region **prior to** taking your instruments to the cadaver. You should identify the following structures and be able to answer the following questions:

- Can you identify the gross anatomical features of the stomach: **the body, greater and lesser curvature, cardia, cardial notch, fundus, pylorus and pyloric sphincter? What are rugae and what is their function? What is chyme?** If any of these structures are difficult to demonstrate in your cadaver, use the prosected stomach in the Abdominal Organs Teaching Bin.
- Your TA will ask you to identify the branches of the celiac trunk, using a diagram, such as this:  . **Be able to state whether each artery is retroperitoneal or intraperitoneal**. If it is intraperitoneal, be able to **name the ligament or mesentery that contains the artery**.
- What structures form the left lateral border of the lesser sac?

If you feel you are ready to proceed, ask your TA to check that you understand the preceding content adequately enough to move on to the next slide and the dissection of the common hepatic artery, its branches, and related structures.

10.4 Progress Check 1





TASK

CUT a notch

out of the anterior border of the left lobe of the liver. This will allow you to more clearly see the structures of the foregut.

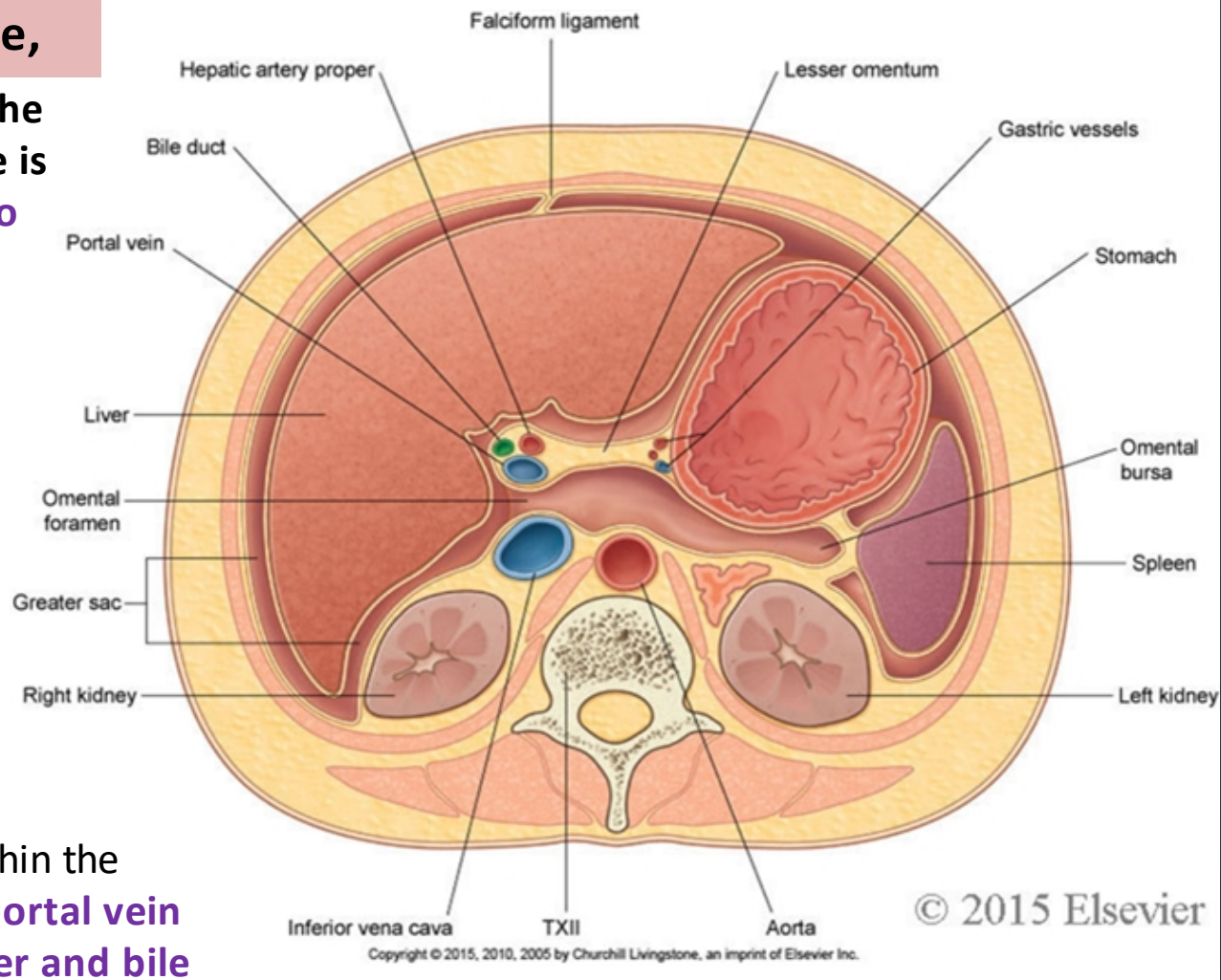
Be careful not to cut into the porta hepatis, but remove enough tissue to more easily see the lesser omentum and the relationship between the stomach and the porta hepatis. This is one of the few times that I will suggest that you use a scalpel on any structure deep to the dermis!

It is best to remove the liver tissue in pieces until you are satisfied with your field of view, although one member of your group will still need to retract the inferior border of the right lobe of the liver.

TASK

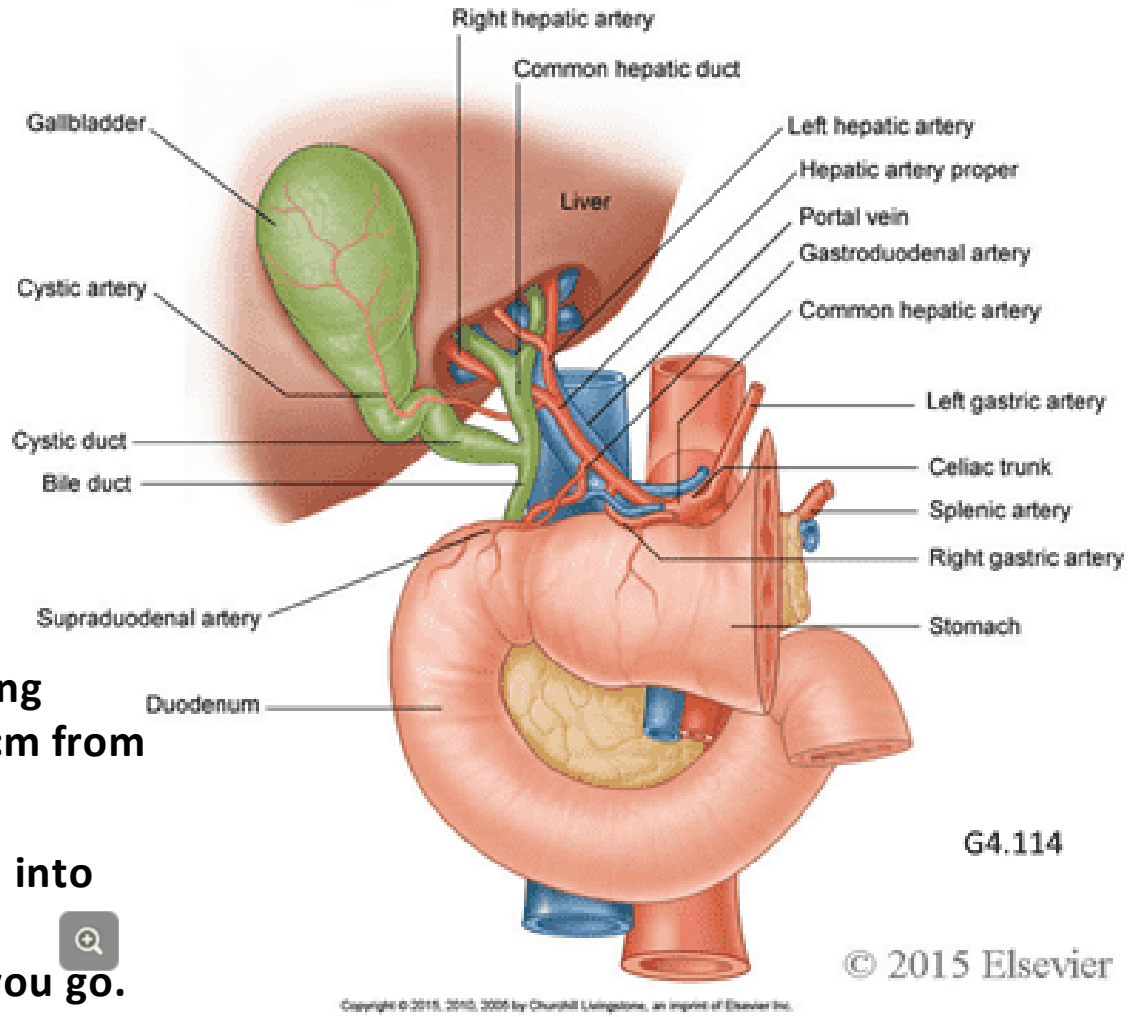
FROM the cadaver's right side, insert your left index finger into the omental foramen. What structure is anterior to your finger? inferior to your finger? superior to your finger?

Realize, with the help of the accompanying figure, that the IVC is posterior to your finger. Also, see from the illustration that the hepatoduodenal ligament contains the common bile duct, hepatic artery proper and the hepatic portal vein.



Note the position of these structures within the hepatoduodenal ligament: **the hepatic portal vein is posterior to the hepatic artery proper and bile duct, and the bile duct is lateral to the artery.** Know that the hepatoduodenal ligament also contains autonomic nerves and lymphatic vessels.

You will start the dissection by exposing the **right gastric artery** located between the serous layers of the lesser omentum, along the right side of the lesser curvature of the stomach. The reason we start with this vessel is because it is small and easily broken. Once identified, you will trace it toward its origin from either the **hepatic artery proper** or the **common hepatic artery**.



TASK

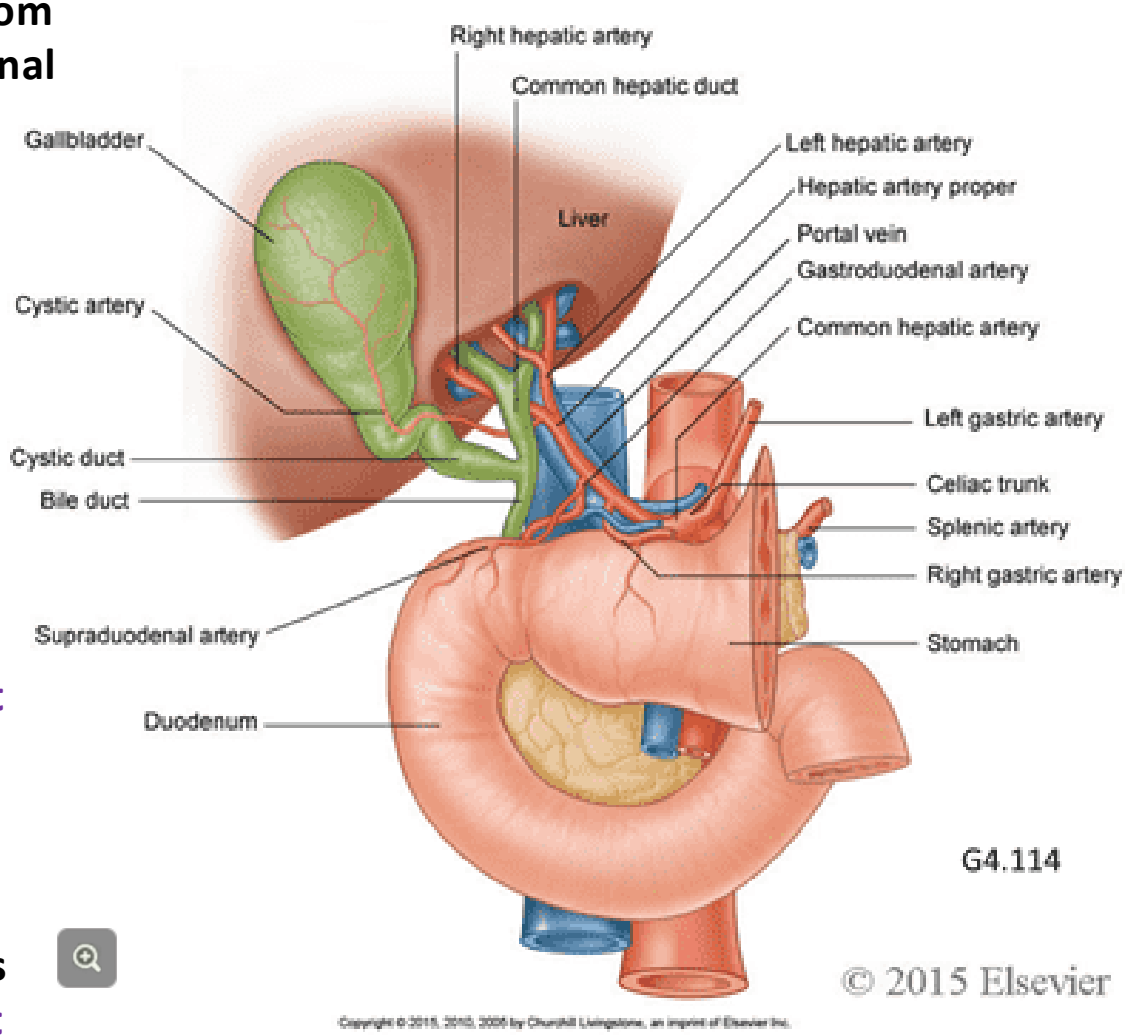
CAREFULLY, using blunt dissection, remove the serous membrane from the anterior surface of the lesser omentum on the right side of the lesser curvature of the stomach. Running parallel to the lesser curvature, and about 1 cm from it, you will encounter the right gastric artery.

Trace the right gastric artery to the right, and into the hepatogastric ligament, to find its origin, dissecting the serous membrane carefully as you go. The right gastric artery will lead you to either the common hepatic artery or the hepatic artery proper.

TASK

CAREFULLY, using blunt dissection, continue to remove serous membrane from the anterior surface of the hepatoduodenal ligament to expose the hepatic artery proper and the common bile duct. The artery is medial to the duct. Posterior to these two structures, you will encounter the hepatic portal vein. The artery is robust, but the bile duct and portal vein are thin-walled, so exercise particular caution in cleaning these latter two structures.

Trace the bile duct toward the liver and gall bladder, dissecting carefully as you go. Find the point at which the common bile duct is formed by the union of the cystic duct, which drains the gall bladder, and the common hepatic duct, which drains the liver. Continue to dissect the common hepatic duct toward the porta hepatis until you observe its formation from the union of the right and left hepatic ducts.



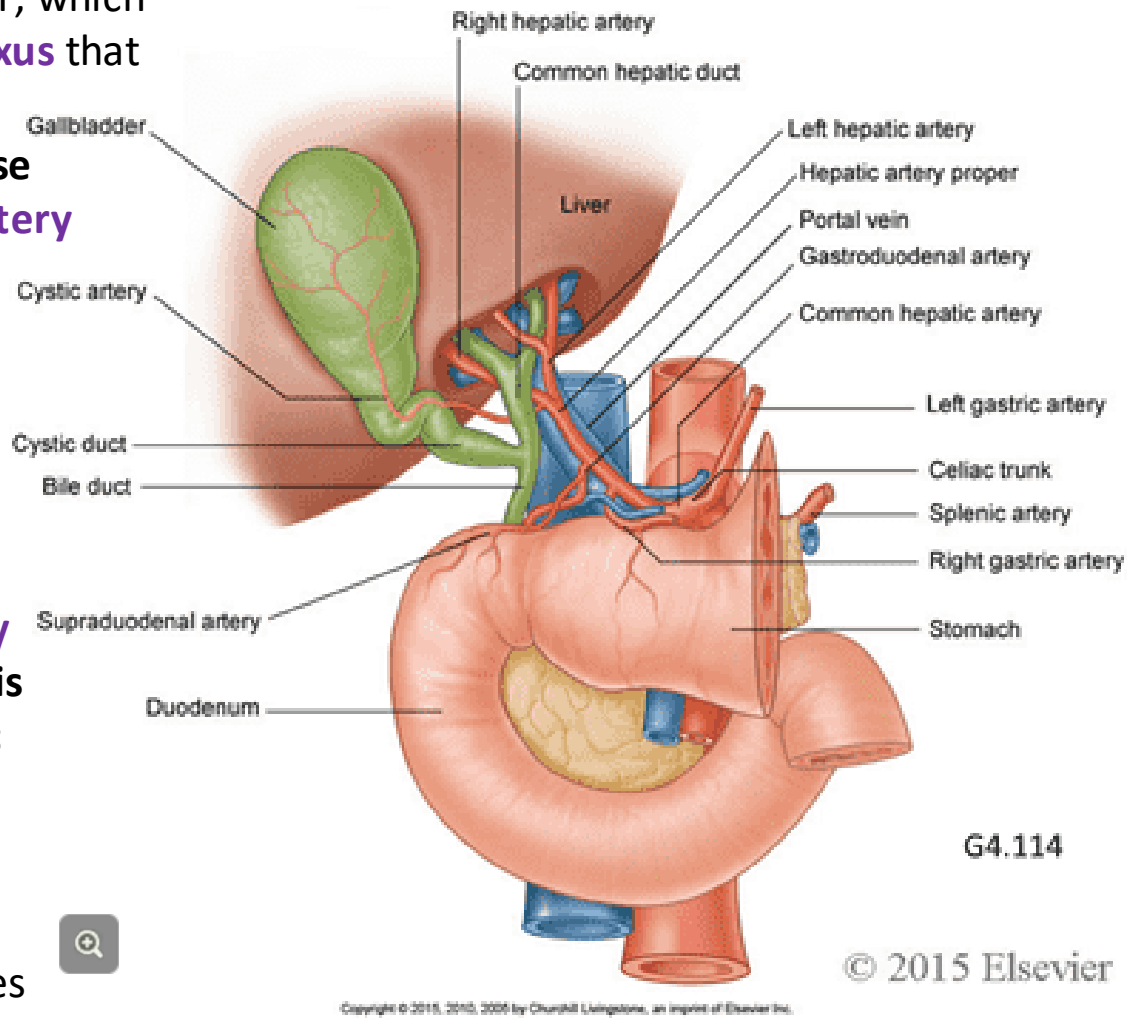
TASK

NOW dissect the hepatic artery proper.

It will appear to be surrounded by tough CT, which is really autonomic fibres of the **celiac plexus** that innervate the liver. **Remove these nerve fibres in order to create a clean dissection. Exercise caution, however, because the right gastric artery often arises from the hepatic artery proper to descend within the hepatogastric ligament to the lesser curvature of the stomach. Maintain the integrity of the right gastric artery.**

Trace the hepatic artery proper toward the porta hepatis, where it bifurcates to form the left and right hepatic arteries. The cystic artery usually arises from the right hepatic artery. It is small and fragile; if possible, identify the cystic artery and clean it as it travels with the cystic duct to the gallbladder.

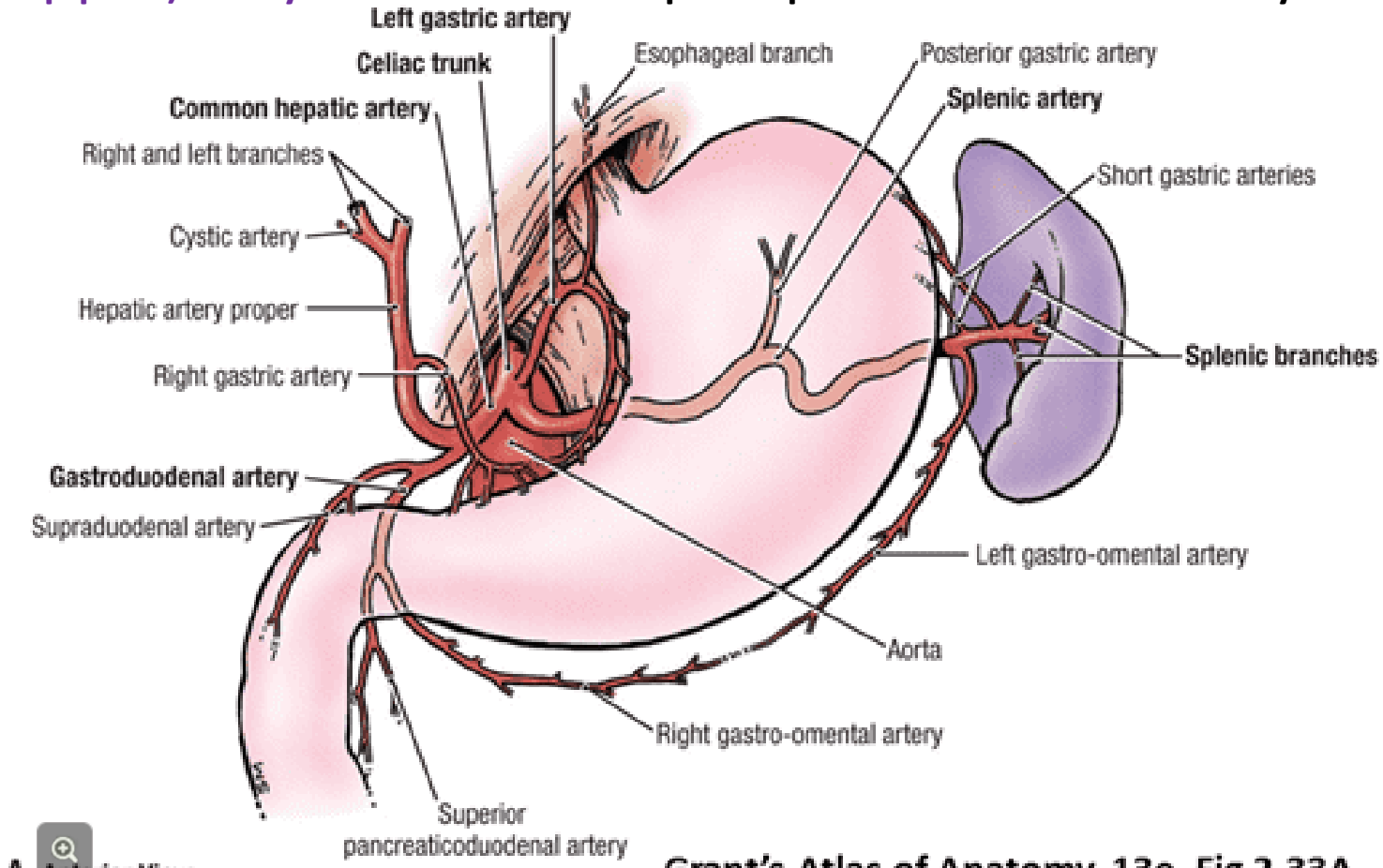
Lymphatic vessels are too small and delicate to dissect, but you might notice hepatic lymph nodes as you work. Remove these lymph nodes in order to create a clean dissection.



TASK

Follow the hepatic artery proper inferiorly until you find its origin

as a branch of the retroperitoneal common hepatic artery. Identify the other branch of the common hepatic artery, the gastroduodenal artery. Continue to clean the gastroduodenal artery as it passes posterior to the first part of the duodenum, and until it bifurcates to form the right gastro- omental (gastroepiploic) artery and the anterior superior pancreaticoduodenal artery.



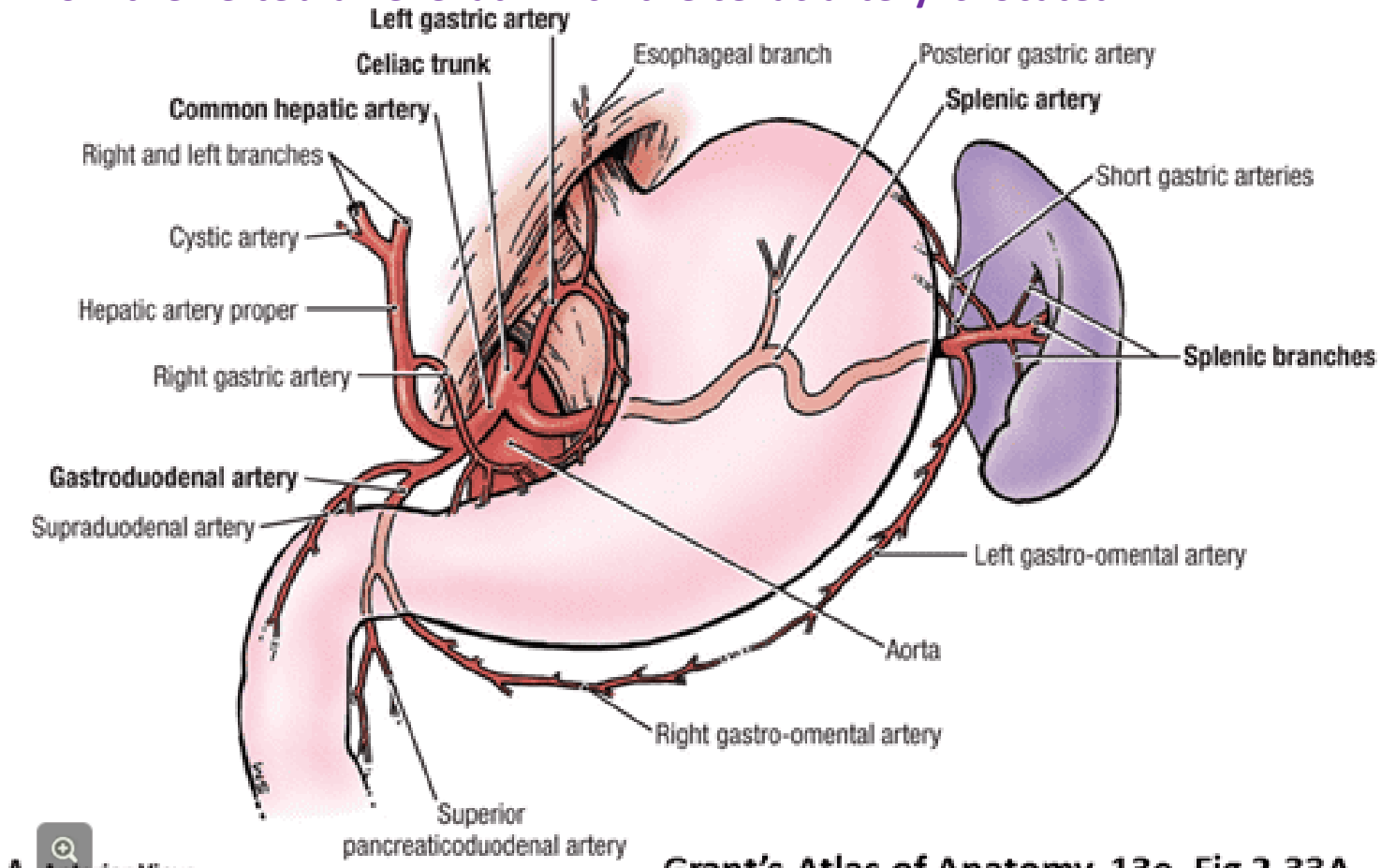
A. Anterior View

Grant's Atlas of Anatomy, 13e, Fig 2.33A

TASK

TURN your attention to the common hepatic artery and clean it toward its origin as a branch of the celiac trunk. Clean the celiac trunk and notice that it is very short, usually less than 2 cm in length. The celiac trunk arises from the anterior surface of the abdominal aorta as it passes through the aortic hiatus of the diaphragm. **Since you know the vertebral level at which the aortic hiatus is located, you know the vertebral level at which the celiac artery is located.**

Identify the other two branches of the celiac trunk, the left gastric artery and the splenic artery. Again, I recommend blunt dissection with large forceps and large scissors.



Grant's Atlas of Anatomy, 13e, Fig 2.33A

Since the last Progress Check, you have **dissected** and **clearly exposed** the following structures:

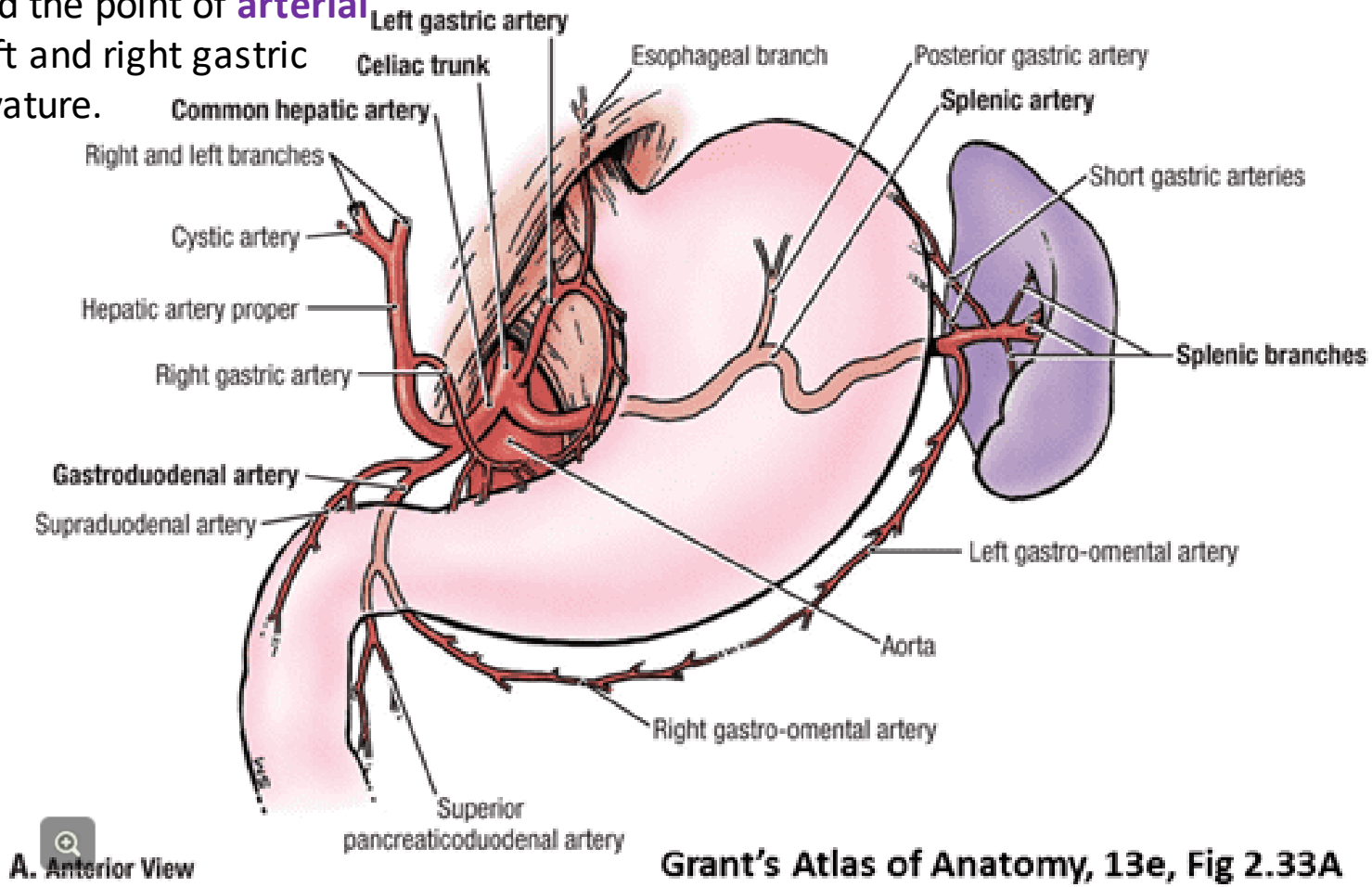
- right gastric artery
- hepatic artery proper, common bile duct, and hepatic portal vein
- cystic artery and cystic duct
- common hepatic duct, right and left hepatic ducts, right and left hepatic arteries
- gastroduodenal artery and the origin of the right gastro-omental artery
- common hepatic artery
- celiac trunk and the origins of the splenic artery and left gastric artery

Pause here to assess your learning. Quiz each other thoroughly. If you are satisfied with your ability to **identify these structures**, move on to the next phase of the exercise.

TASK

CLEAN the left gastric artery toward the junction of the esophagus and stomach.

There, identify its esophageal branch ascending through the esophageal hiatus to supply the terminal third of the esophagus. Trace the continuation of the left gastric artery through the lesser omentum, along the lesser curvature of the stomach. Ideally, you will find the point of arterial anastomosis between the left and right gastric arteries along the lesser curvature.

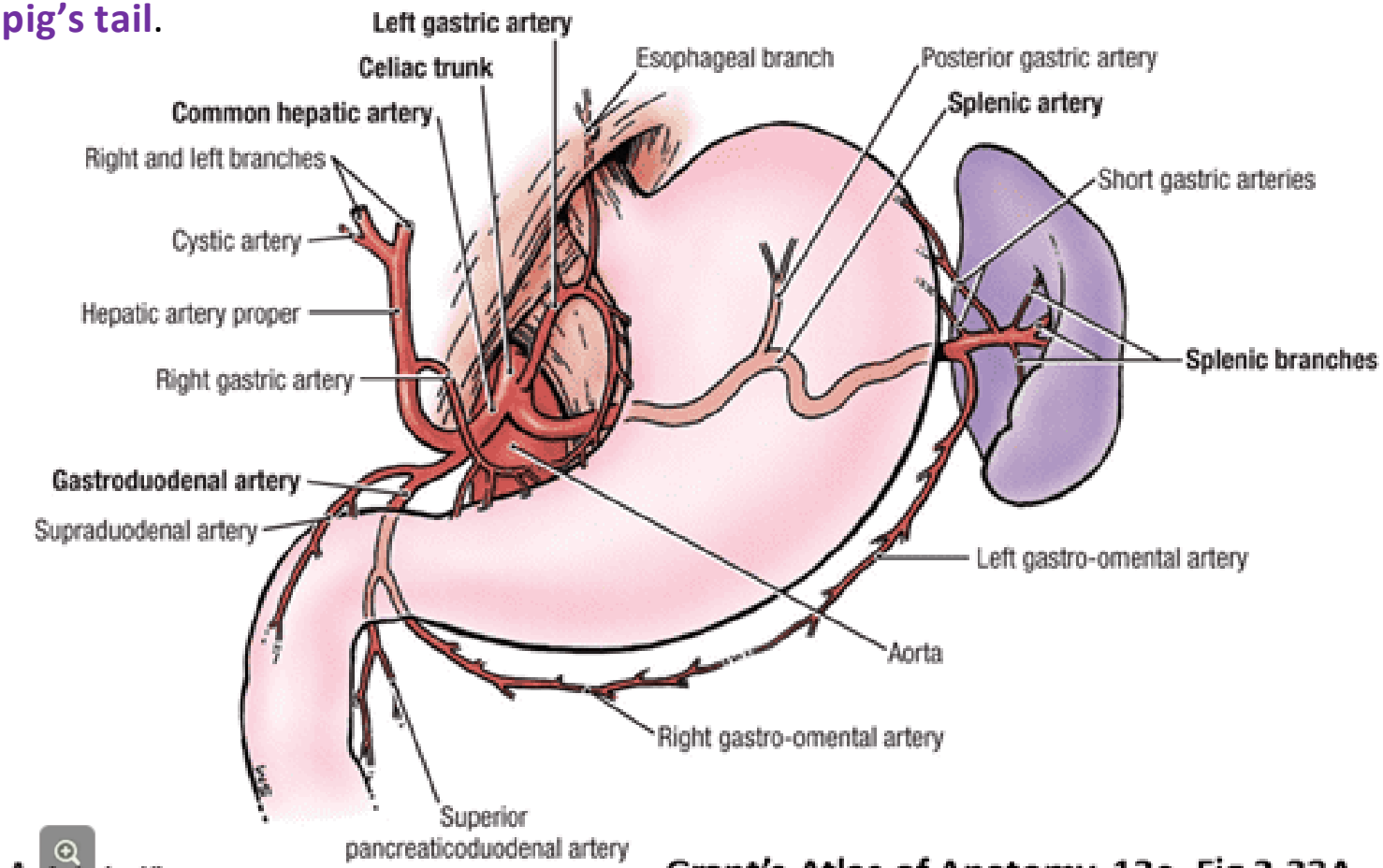


Grant's Atlas of Anatomy, 13e, Fig 2.33A

TASK

RETURN to the celiac trunk and clean the splenic artery

The **splenic artery** runs to the left retroperitoneally, in close association with the superior border of the pancreas. **Clean the splenic artery with blunt dissection and note its relationship to the superior edge of the pancreas.** You will find that the splenic artery is characteristically helical in its course, and is thus **reminiscent of a pig's tail**.



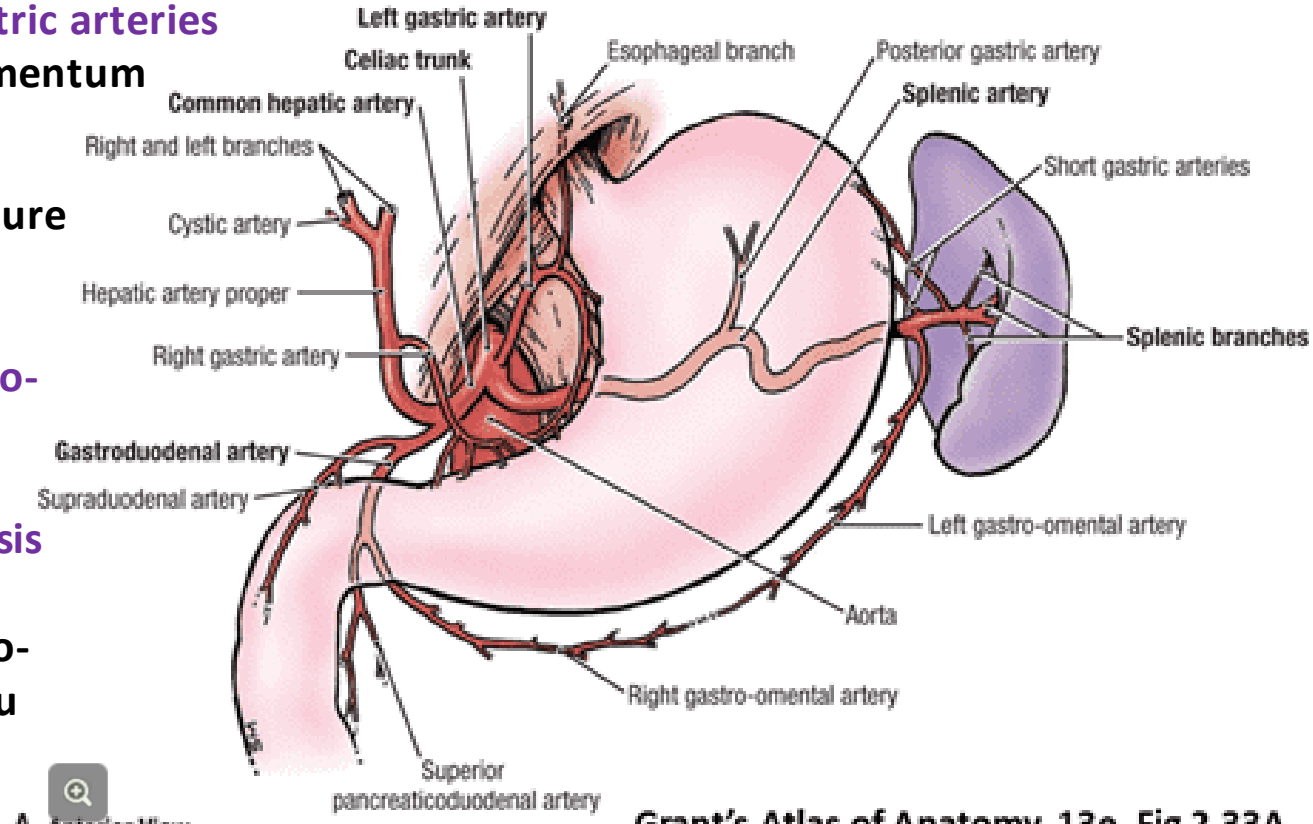
Grant's Atlas of Anatomy, 13e, Fig 2.33A

Turn your attention to the greater omentum. Running within the greater omentum, **about 2 cm from the greater curvature of the stomach**, are the left and right **gastro-omental (gastro-epiploic) arteries**.

TASK

Adjacent to the body of the stomach, break through the greater omentum using blunt dissection and identify the left gastro-omental (gastroepiploic) artery. Trace it back toward the left until you find its origin as a branch of the splenic artery. Clean the splenic artery in the hilum of the spleen as well as back toward the celiac trunk. Look for the short gastric arteries which ascend within the greater omentum to the fundus of the stomach.

About 2 cm from the greater curvature of the stomach, in the region of the pylorus, break through the greater omentum to identify the right gastro-omental artery. Clean it to the left along the greater curvature; ideally you will find the point of anastomosis of the right and left gastro-omental arteries. Now follow the right gastro-omental artery to the right until you find its continuation with the gastroduodenal artery, which you identified earlier.



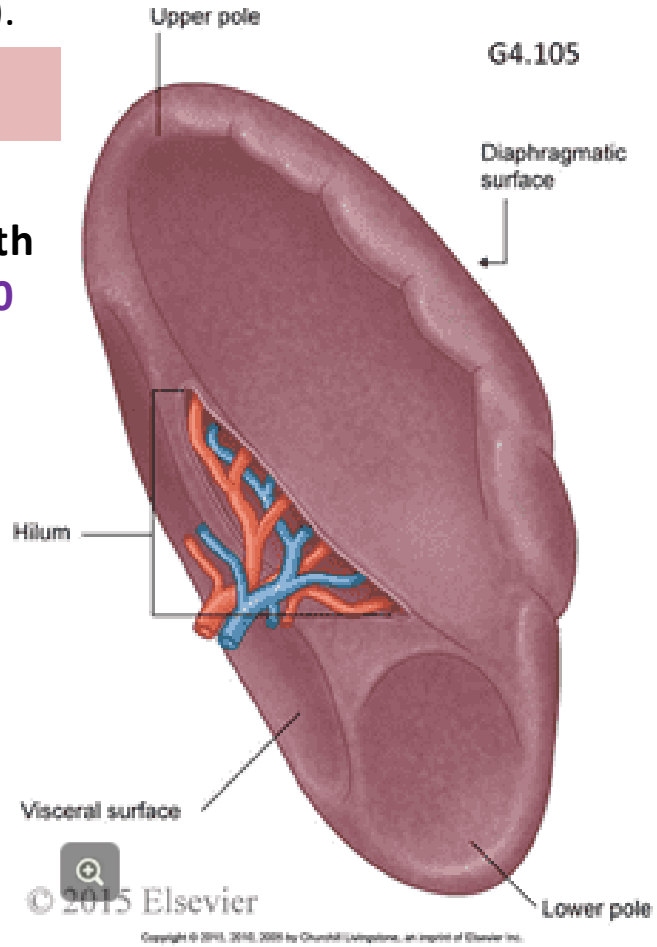
A. Anterior View

Grant's Atlas of Anatomy, 13e, Fig 2.33A

Because of its large blood volume, the spleen, if lacerated, bleeds profusely into the peritoneal cavity, as may occur as a result of a rib fracture or a penetrating wound. Also, it is important to remember that the spleen may be punctured accidentally during a pleural tap (thoracentesis).

TASK

USING your left hand, retract the fundus of the stomach to the right and grasp the spleen with your right hand. Pull the spleen anteriorly in order to identify its features. Note the smooth diaphragmatic surface of the spleen, which lies at the level of ribs 9, 10 and 11. Identify its sharp borders and its visceral surface. You have already observed the four organs adjacent to the visceral surface of the spleen: the stomach, the pancreas, the left kidney and the transverse colon at its left colic flexure.



The spleen, as you know from your understanding of the immune system, processes blood for antigen and for spent formed elements. The spleen is wholly intraperitoneal, except at its hilus.

INFO

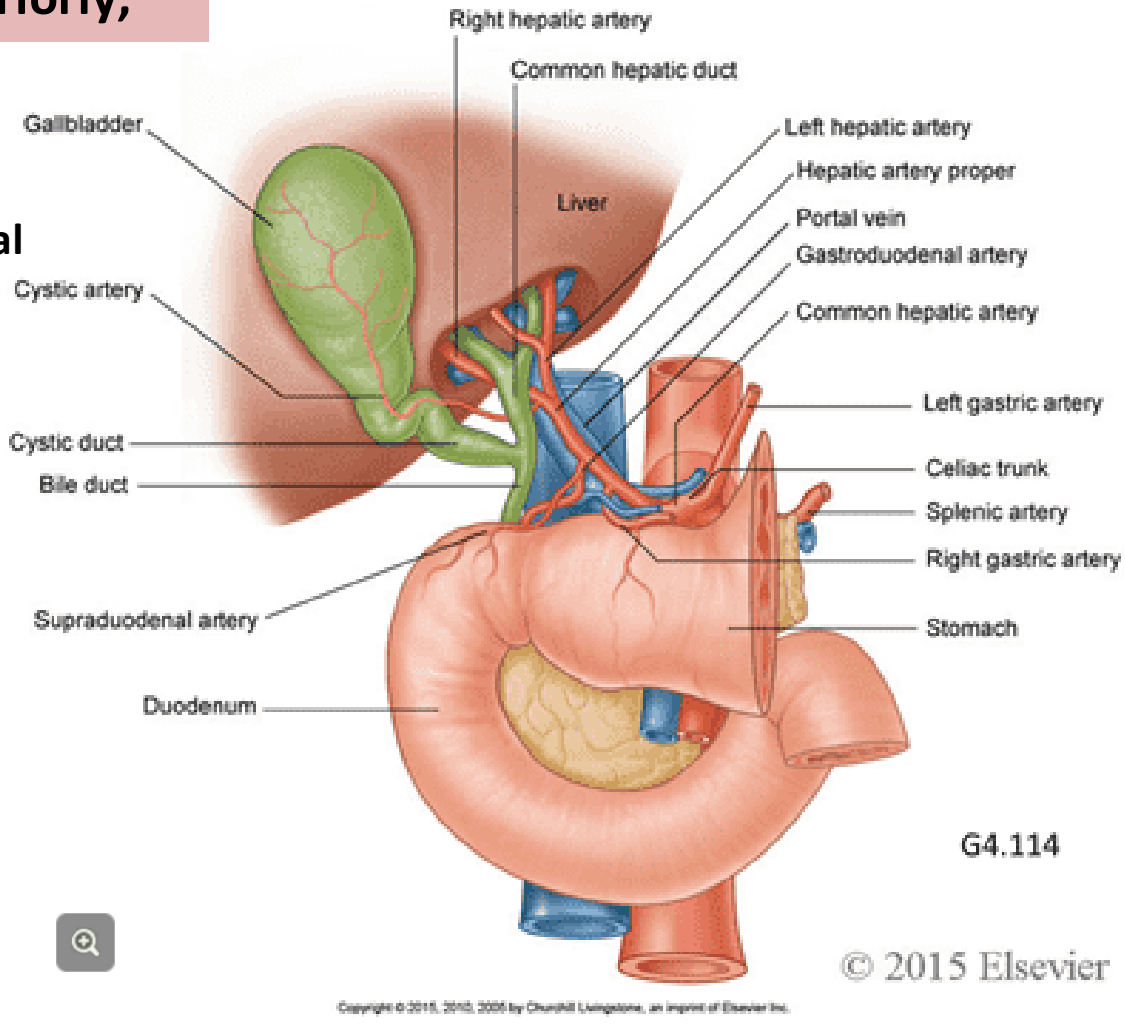
SPLEEN

Thus, the spleen's relationship to **ribs 9, 10, and 11** of clinical importance in **rib fractures** and **thoracentesis**. A variety of infections and disease processes might cause an enlarged spleen (**splenomegaly**). If, during physical examination, the spleen can be palpated inferior to the costal margin, it is considered to be enlarged.

Now revisit the hepatoduodenal ligament and again identify the hepatic portal vein where it lies posterior to both the hepatic artery proper and the bile duct.

TASK

CLEAN the hepatic portal vein superiorly, into the porta hepatis and identify its terminus as the right and left portal veins. Now clean the hepatic portal vein inferiorly until it becomes retroperitoneal and passes posterior to the first part of the duodenum.



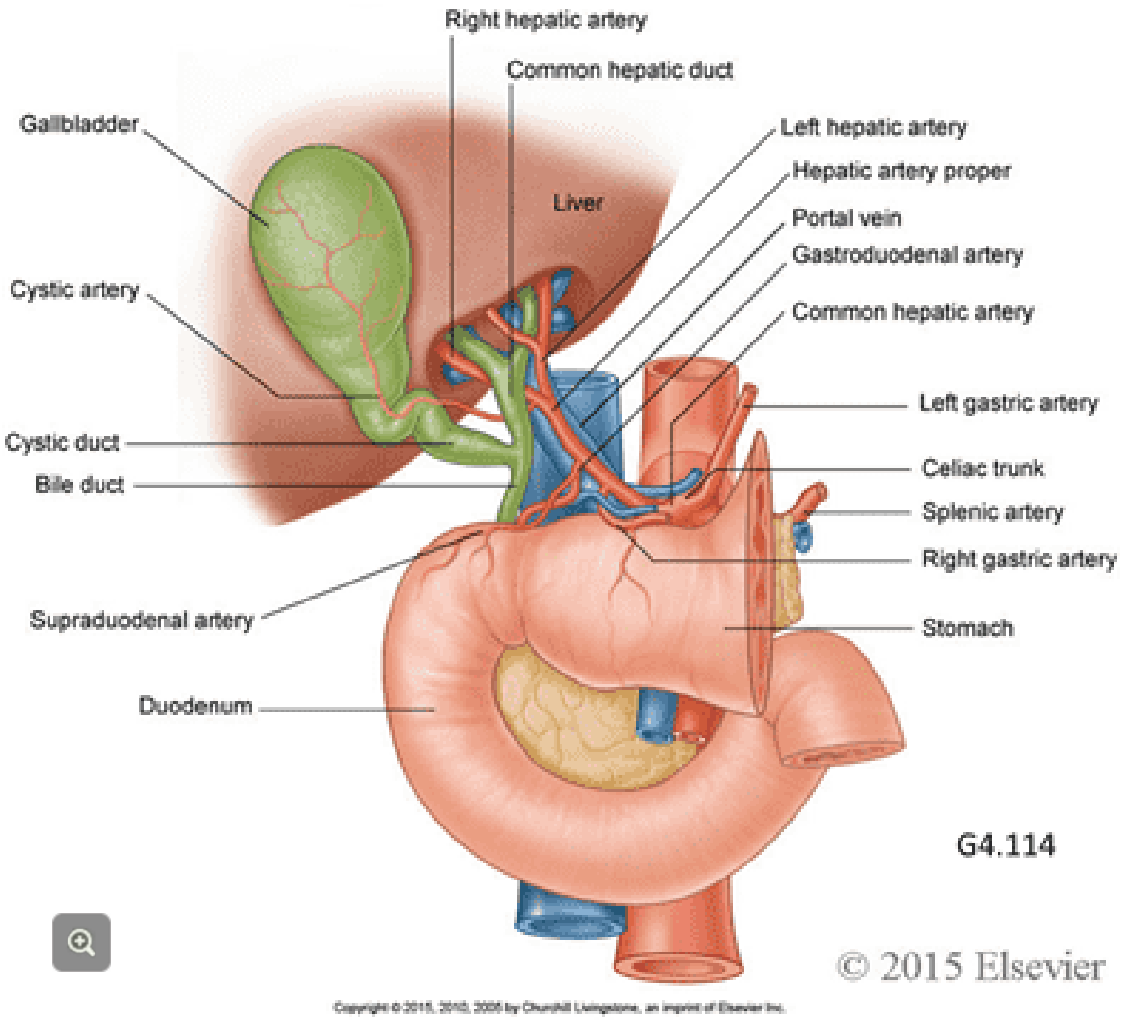
The gallbladder stores and concentrates bile. After death, the active processes that contain bile within the lumen of the gallbladder cease, and bile leaches across the wall of the gall bladder, staining adjacent organs dark green.

TASK

ONE colleague should retract

the inferior border of the right lobe of the liver, and the other can work the gall bladder free using blunt dissection. Identify the fundus, body and neck of the gallbladder.

Using scissors, cut through the wall of the gallbladder, starting at the fundus and continuing through the body and neck, and into the cystic duct. Gallstones might be present; if so, remove them.



Since the last Progress Check, you have **dissected** and **clearly exposed** the following structures:

- the esophageal branch of the left gastric artery passing through the esophageal hiatus
- the full course of left gastric artery and its anastomosis with the right gastric artery
- the splenic artery adjacent to the superior border of the pancreas, and into the hilum of the spleen
- the short gastric arteries ascending to the fundus of the stomach
- the full course of the left gastro-omental artery, from its origin as a branch of the splenic artery to its anastomosis with the right gastro-omental artery
- the full course of the right gastro-omental artery from its origin as a branch of the gastroduodenal artery to its anastomosis with the left gastro-omental artery
- hepatic portal vein and right and left portal veins
- the fundus, body and neck of the gall bladder

If you are satisfied with the **quality of your dissection**, and your **ability to identify these structures** and **answer these questions**, call your TA over for confirmation and for permission to clean up.

11.2 Study of Abdominal Organs Prosections

What you'll need:

SPECIMENS

- Two Abdominal Organs Teaching Bins

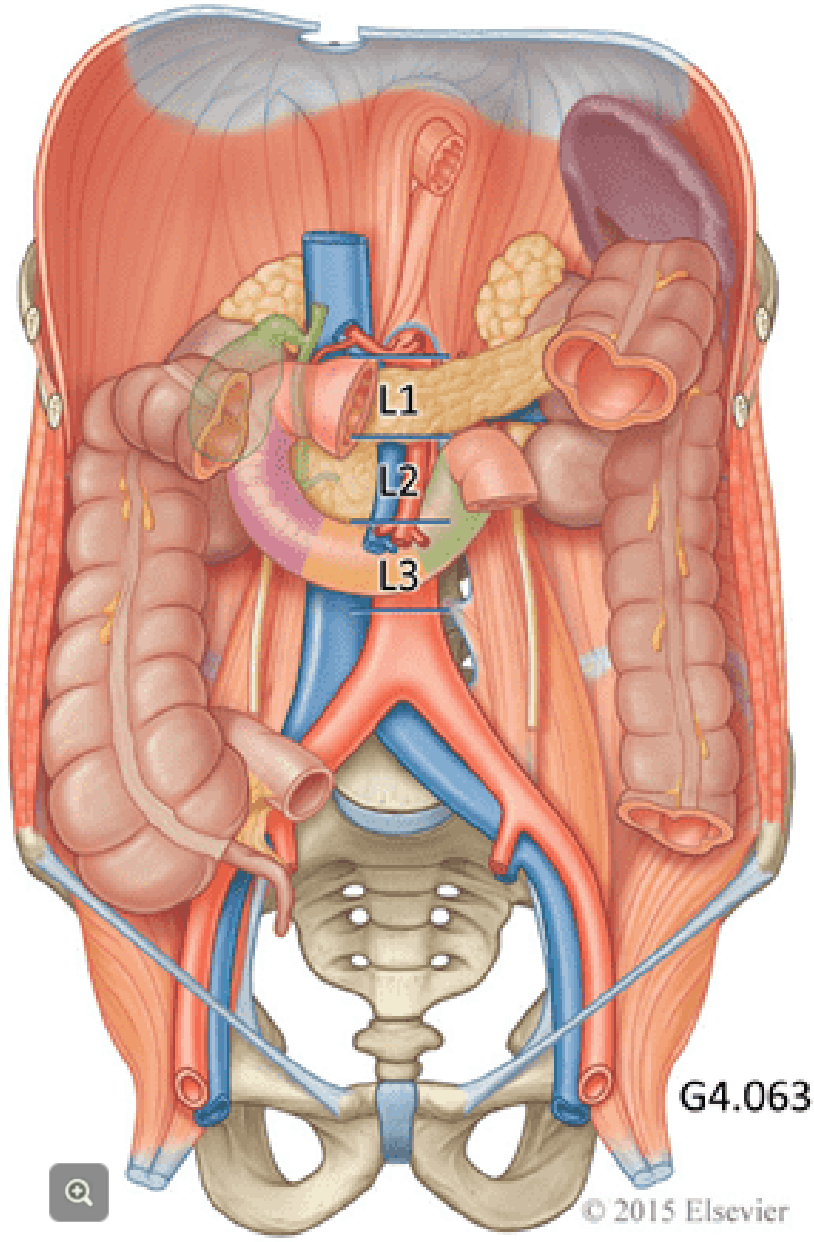
INSTRUCTIONS 11.2

Over the course of this full-day lab, students will in turn take a break from working on their dissection of the foregut to study the prosected abdominal organs that are available on the table in front of the big screen. This will occur as follows:

	9:00 - 10:30 am	10:30 am – 12 noon	1:00 - 2:30 pm	2:30 - 4:00 pm
Exercise 11.2	Pairs 1	Pairs 3	Pairs 2	Pairs 4

When you have completed this dissection, you will be able to identify and / or describe:

- the anatomy of the stomach including its internal features
- the difference between systemic (caval), pulmonary and hepatic portal veins
- the formation of the hepatic portal vein
- the features of the liver including its surfaces, their features, its bare area and ligaments
- hepatic segments
- the distinguishing features, external and internal of the duodenum, jejunum and ileum
- the surfaces and features of the spleen
- the subdivisions of the pancreas and their relationship to adjacent organs and vessels



The Abdominal Organs Teaching Bin contains a variety of prosected specimens, each **wrapped in a moist cloth and tied in a bag with minimal air**. Note that the appropriate tag is on the bag. This is how the specimens should be put into the bin at the end of the day.

The first persons to complete this exercise today will remove the specimens from the bin, unwrap them and place them on the table for study covered by their cloth. Place the plastic bags and tags in the bin, replace its lid and put the bin under the table.

- two livers, one with the diaphragm attached and the other in isolation
- open stomach
- three prosections of the small intestine: i) the gastroduodenal junction, ii) the duodenal-jejunal junction, and iii the ileocecal junction
- isolated spleen
- pancreas complex

Uncover each specimen as needed, and when you're done with it, moisten it and cover it with its cloth.

The lasts persons to complete this exercise today will replace the specimens in the bin as they were found: moistened, wrapped, bagged with minimal air and with the CORRECT TAG on the bag.

When you are finished studying them, you must **moisten them, wrap them in cloths, put them back in their bags with minimal air, tie the bags with the appropriate tags** so that they can be found by others, **put them in the bin and seal it**.

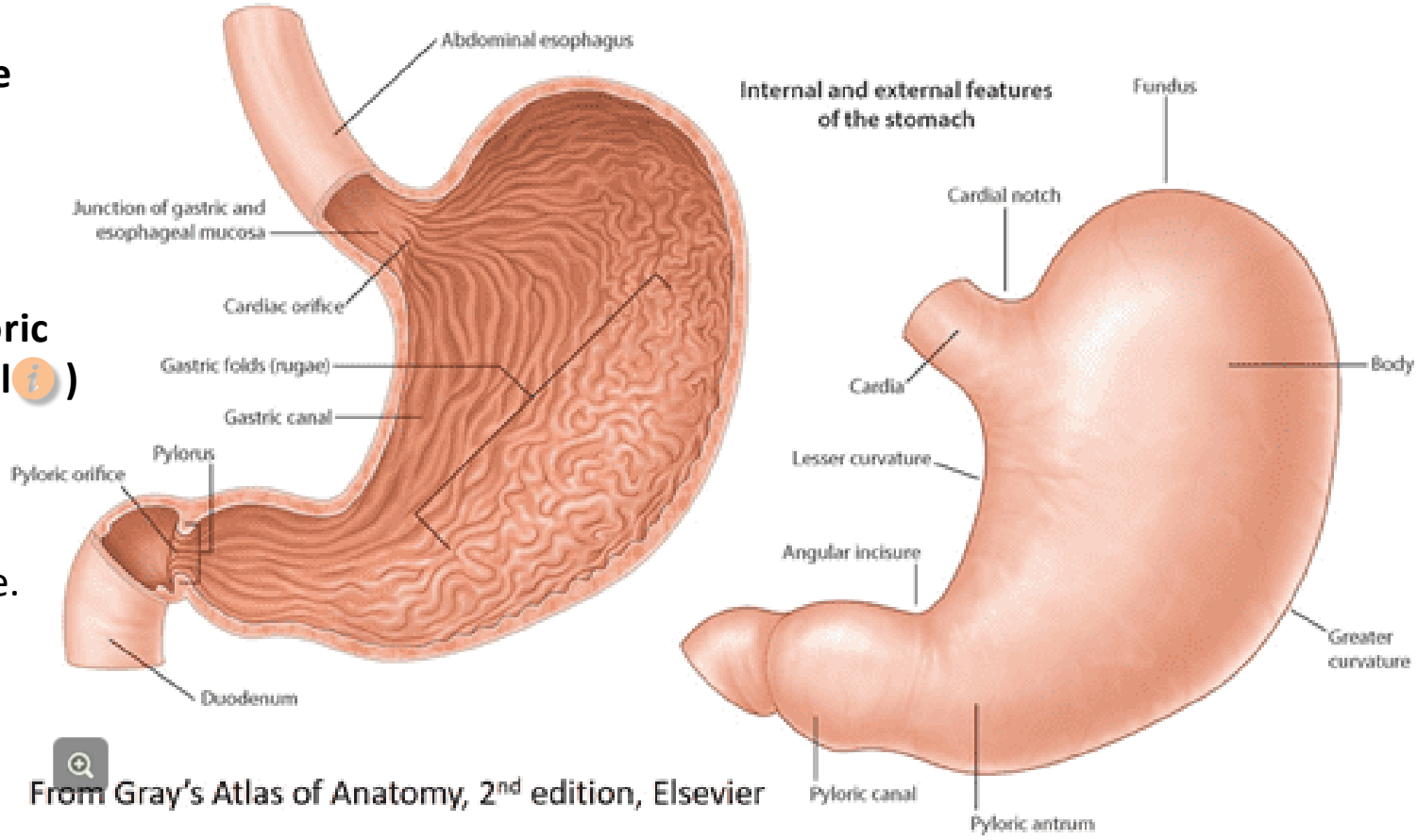
Unwrap the specimen marked “Stomach”. Lay it out on a table.

TASK

Review the features of stomach. Identify the:

- **body**
- **greater curvature**
- **lesser curvature**
- **cardia**
- **cardial notch**
- **fundus**
- **pylorus (inc. pyloric antrum and canal)**
- **pyloric orifice and sphincter**

Open the stomach and inspect its internal surface.



From Gray’s Atlas of Anatomy, 2nd edition, Elsevier

TASK

Identify the:

- **rugae**

Rugae are **longitudinal folds** of the gastric mucosa and submucosa. They flatten out as the stomach fills, and thus function to permit expansion and increased volume as needed.

Moisten the specimen and cover it with a damp cloth; it needs to be handy for your Progress Check.

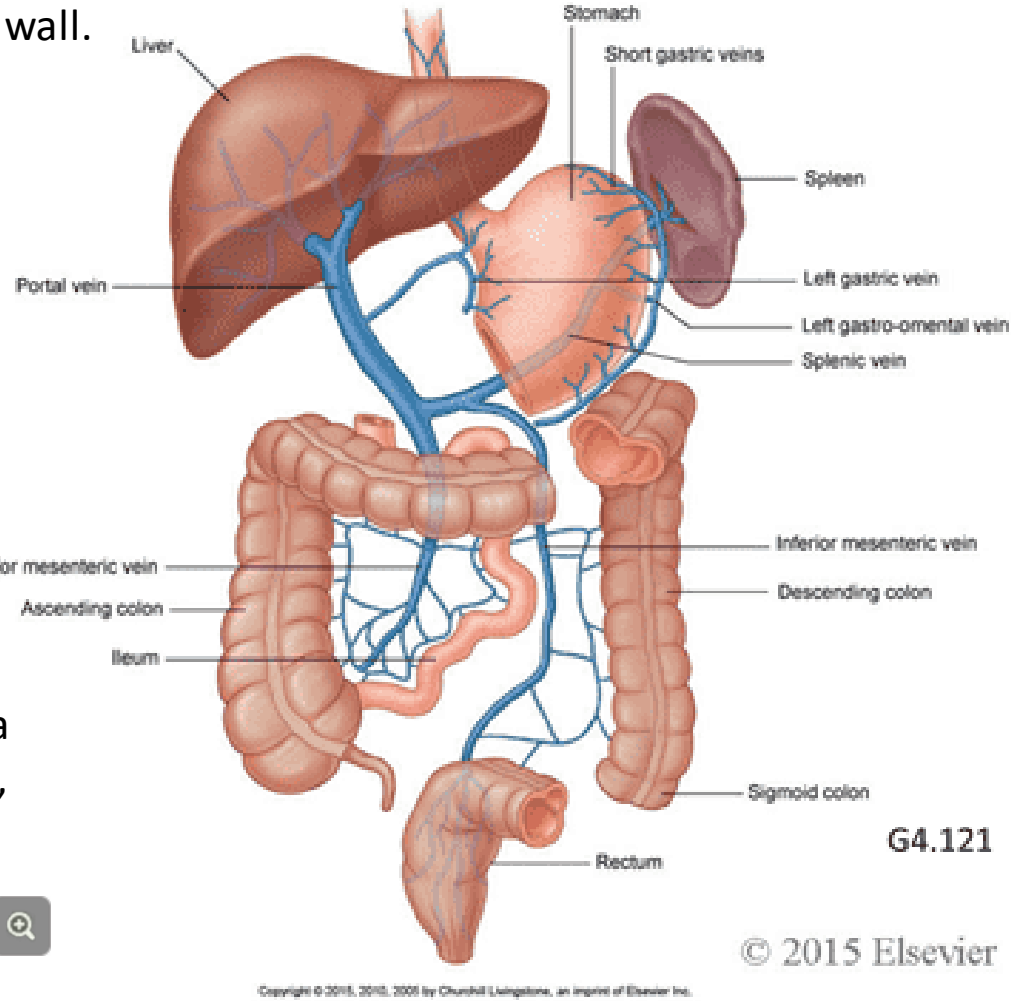
Systemic veins drain into the SVC or IVC. Systemic veins are thus, sometimes, called **"caval" veins**. Examples are the veins draining the head and neck, limbs and body wall.

Pulmonary veins drain the lungs.

Veins of the hepatic portal system ("**portal veins**") drain the digestive tract first to the liver, and only after processing in this organ, does the venous blood then drain into the IVC. In this way, portal veins are distinct from systemic veins.

As illustrated, **portal veins respect the division of the digestive tract into the foregut, midgut and hindgut**. The hindgut is drained by the **inferior mesenteric vein**. The midgut is drained by the **superior mesenteric vein**. The foregut is drained by a combination of vessels that includes the **splenic vein**, the **gastric veins** and the **gastro-omental veins**.

All of these veins ultimately combine to form the **hepatic portal vein**, which runs in the **hepatoduodenal ligament** and drains into the liver at the **porta hepatis**.



TASK

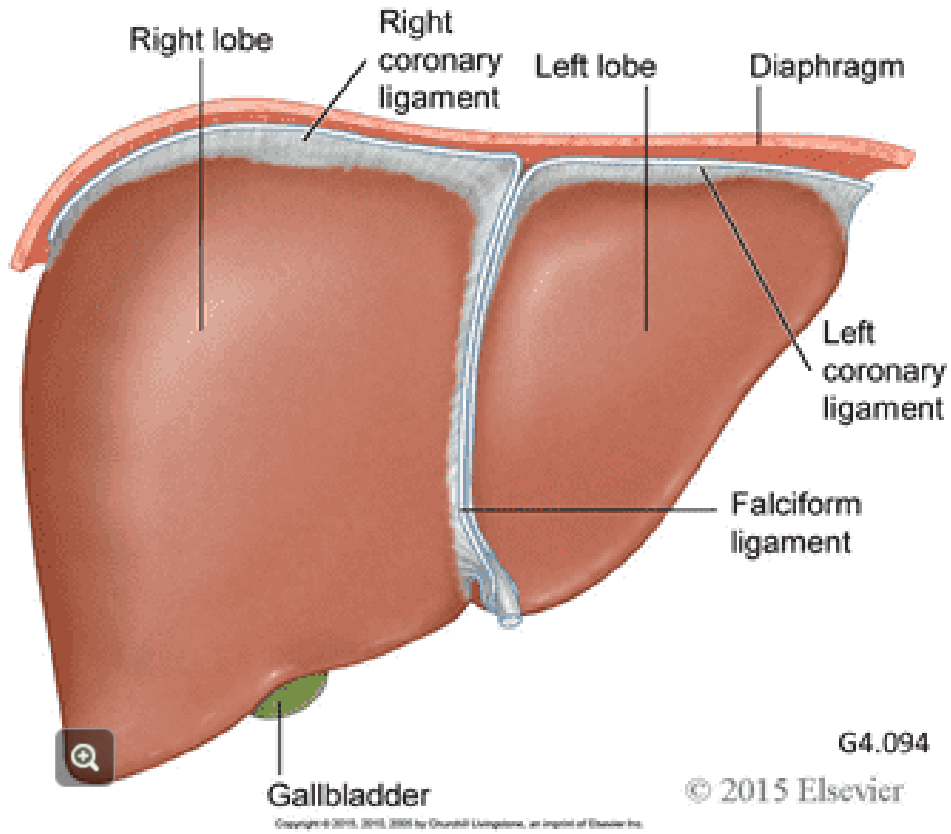
UNCOVER the liver with the attached diaphragm.

Identify the right and left lobes, covered by visceral peritoneum. Identify the falciform ligament, formed as the serous membrane reflects off the right and left lobes and onto the underside of the diaphragm. Follow the falciform ligament to the point where its two laminae diverge to form the right and left coronary ligaments which attach the liver to the underside of the diaphragm.

Place one hand on each of the anterior and posterior surfaces of the left lobe. As you slide your hands up toward the diaphragm to touch the left coronary ligament, you'll find your hands are close together.

Repeat this with the right lobe, and you will find that when you touch the right coronary ligament, your hands are quite far apart!

The surface of the liver between your hands is directly attached to the underside of the diaphragm. It is therefore not covered by visceral peritoneum. This is the bare area of the liver, largely located on the superior surface of the right lobe.

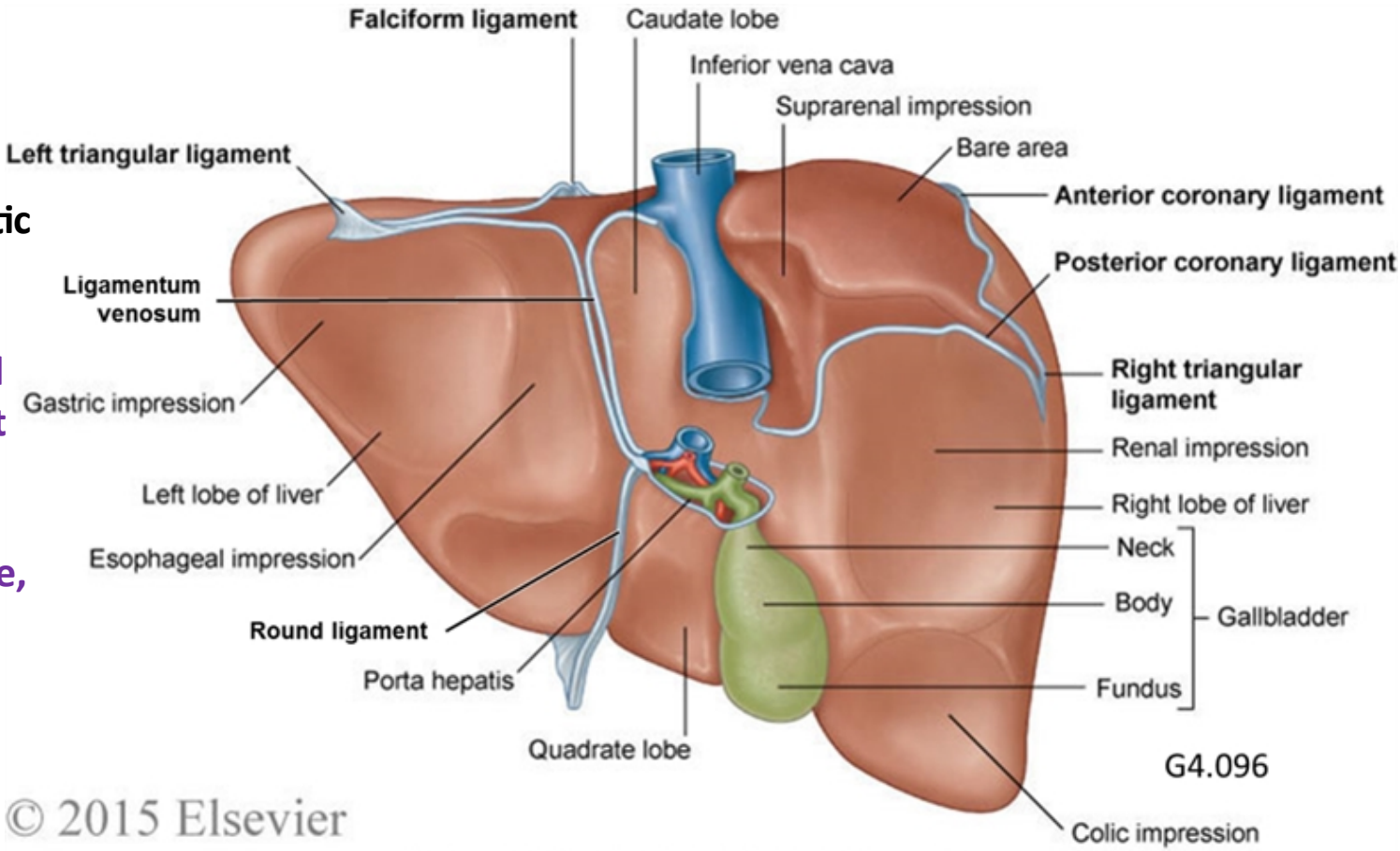


TASK

UNCOVER the isolated liver without the diaphragm.

On the posterior aspect of the diaphragmatic surface, identify the bare area. This surface was fixed by CT to the inferior surface of the diaphragm, and thus is **not** covered by visceral peritoneum. **Around the bare area, note the cut edges of the coronary ligaments, which form the margins of the bare area. Identify the lateral extensions of the coronary ligaments, which are the right and left triangular ligaments.**

Note the sharp anterior border of the liver that separates the diaphragmatic surface from the visceral surface. On the visceral surface, note the H-shaped structures and creases that separate the four anatomical lobes of the liver; identify the right lobe, left lobe, caudate lobe and quadrate lobe.



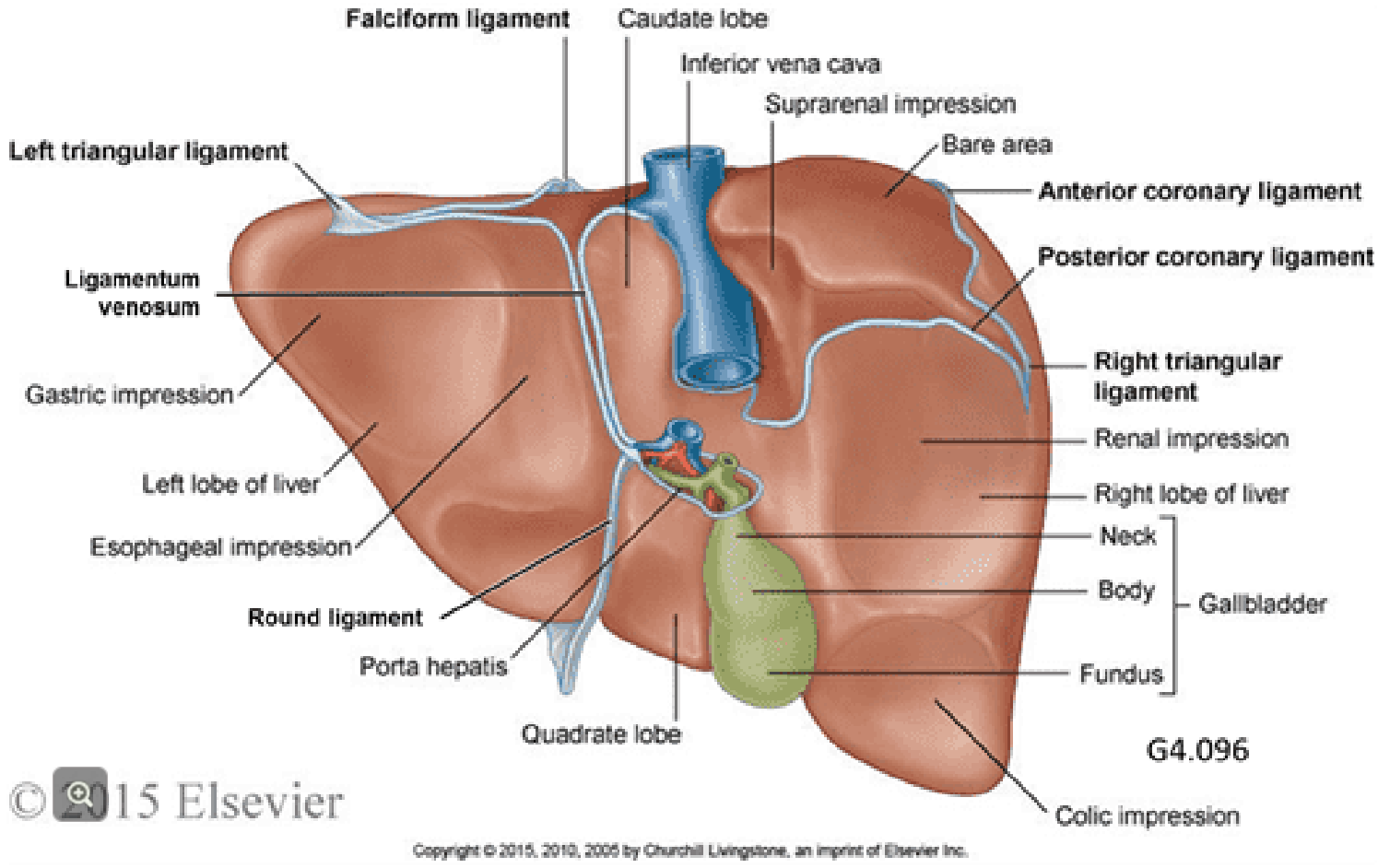
TASK

LOOK at the right pillar of the H; it is formed by the IVC and gallbladder.

Look at the left pillar of the H: it is formed by the falciform ligament and the ligamentum venosum. The two pillars of the H are joined by the porta hepatis and its contents, the hepatic ducts, the hepatic arteries and the hepatic portal vein.

Look for the hepatic veins, which drain the liver into the IVC. There are usually three.

Do not confuse the **hepatic veins** with the **hepatic portal vein**. The hepatic portal vein carries venous blood from the digestive tract to the liver. After this blood has been processed by the liver, the hepatic veins carry venous blood from the liver to the IVC.

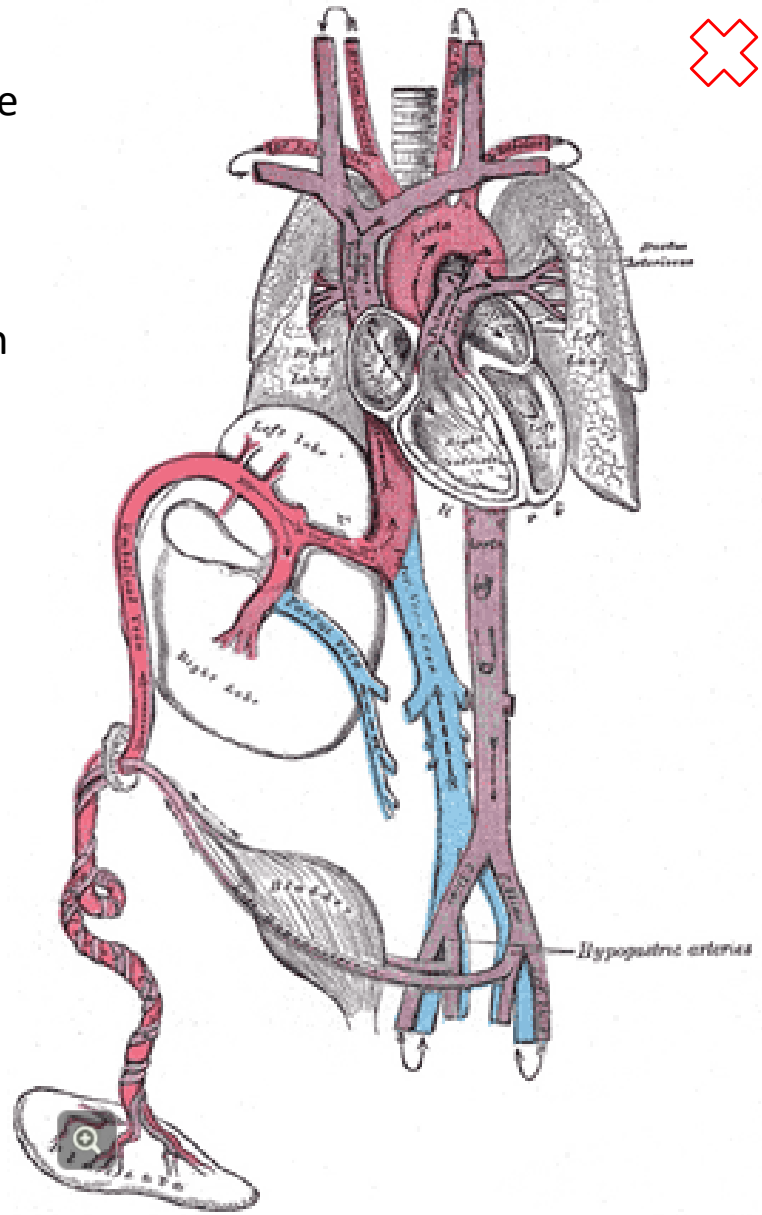


The Fetal Circulation

This diagram, from an early edition of Gray's Anatomy, shows the fetal circulation, and explains the formation of both the **round ligament** of the liver and the **ligamentum venosum**.

The **round ligament** of the liver is a remnant of the **umbilical vein**, which carried oxygenated blood from the placenta, through the umbilicus, to the fetal liver. It is located in the free edge of the falciform ligament.

The **ductus venosus** collected blood from the umbilical vein and carried it to the **IVC**, which delivered it to the **right atrium**. Postnatally, the ductus venosus degenerates, forming the **ligamentum venosum**, which you see on the visceral surface of the liver under study.



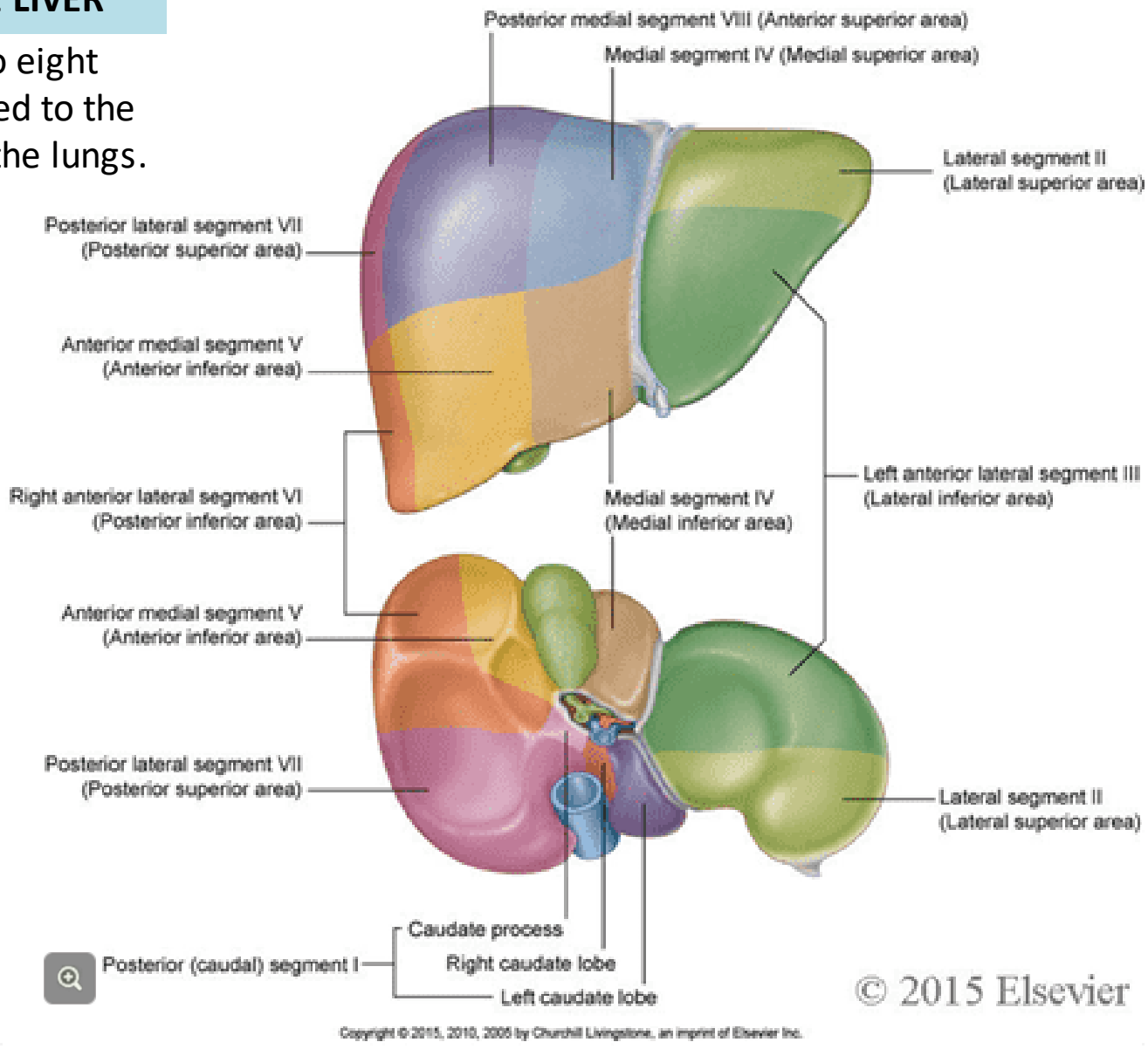
INFO

SEGMENTAL ANATOMY OF THE LIVER

Clinically, the liver is divided into eight **segments**, which can be compared to the bronchopulmonary segments of the lungs.

Each liver segment is independent of the others, being fed by its own branches of the hepatic portal vein and hepatic artery proper, and being drained by a dedicated tributary of the hepatic duct.

Thus, surgical resection of diseased segments can leave, intact, the healthy segments.



***You are not responsible for identifying or learning the names of the liver segments**

Since embarking on this exercise, you have **identified** in a prosection, the following structures:

- stomach: body, greater curvature, lesser curvature, cardia, cardial notch, fundus, pylorus, pyloric canal, pyloric antrum, pyloric orifice, pyloric sphincter, rugae. What is the function of the rugae?
- What is meant by the terms **caval veins**? How do these differ from **portal veins** and **pulmonary veins**? Why are portal and pulmonary veins not caval veins?
- falciform ligament, right and left coronary and triangular ligaments
- the bare area of the liver
- on the visceral surface of the liver, its anatomical lobes: the right, left , quadrate and caudate lobes
- on the visceral surface of the liver, the IVC and hepatic veins, gallbladder, falciform ligament, round ligament, ligamentum venosum, porta hepatis containing hepatic ducts, arteries and the portal vein
- What were the round ligament and ligamentum venosum in the fetus? Describe the fetal circulation.
- Describe what is meant by the term **segment** as it applies to the liver. Why is this clinically important?

Pause here to assess your learning. Quiz each other thoroughly. If you are satisfied with your ability to **identify these structures** and **answer these questions**, move on to the next phase of the exercise.

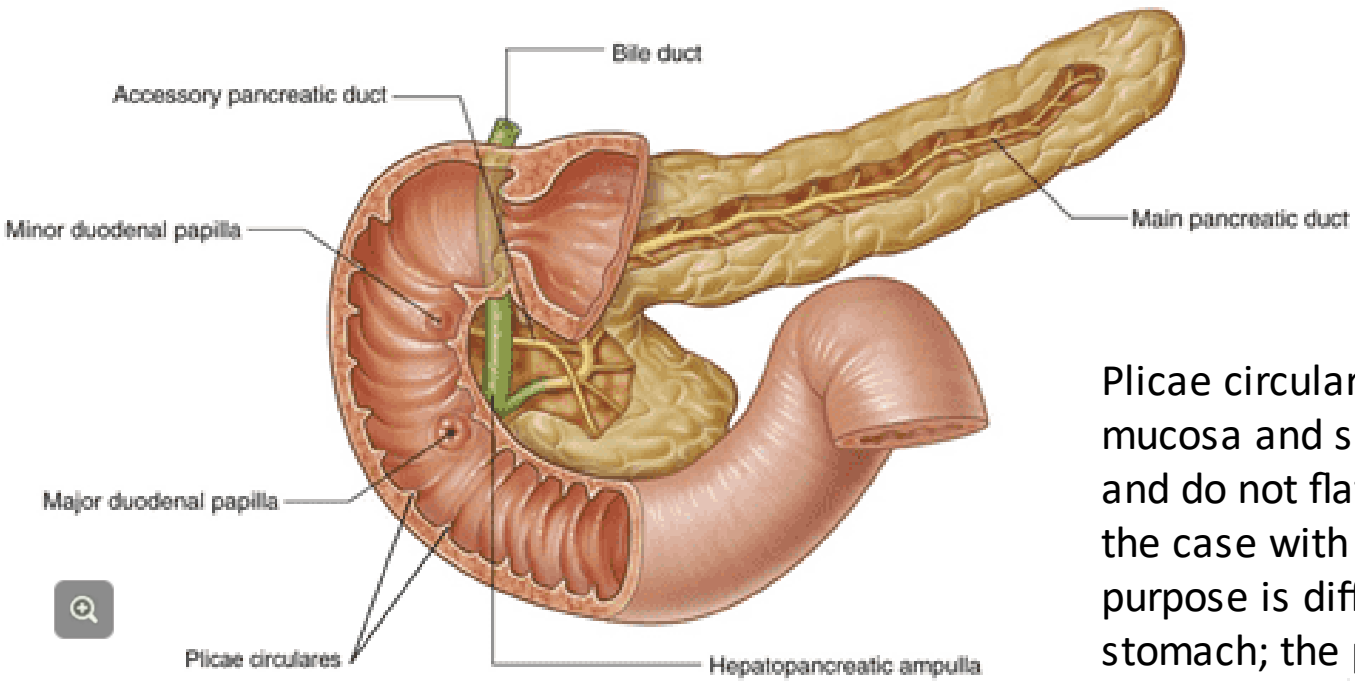
Uncover the three segments of small intestine. Lay the specimens out so that you can compare them.

TASK

Identify, in the specimen of the gastroduodenal junction,

the pylorus, pyloric sphincter, the major duodenal papilla and the plicae circulares.

The **hepatopancreatic ampulla** opens into the duodenum at the **major duodenal papilla**. The papilla is formed by a ring of smooth muscle, the **hepatopancreatic sphincter**, which controls the flow of bile and pancreatic juice into the duodenum.



Plicae circulares are transverse folds of mucosa and submucosa. They are **permanent**, and do not flatten out as the lumen fills, as is the case with the rugae of the stomach. Their purpose is different from that of rugae of the stomach; the plicae circulares are found **only in the small intestine** and function to **increase surface area for nutrient absorption**.

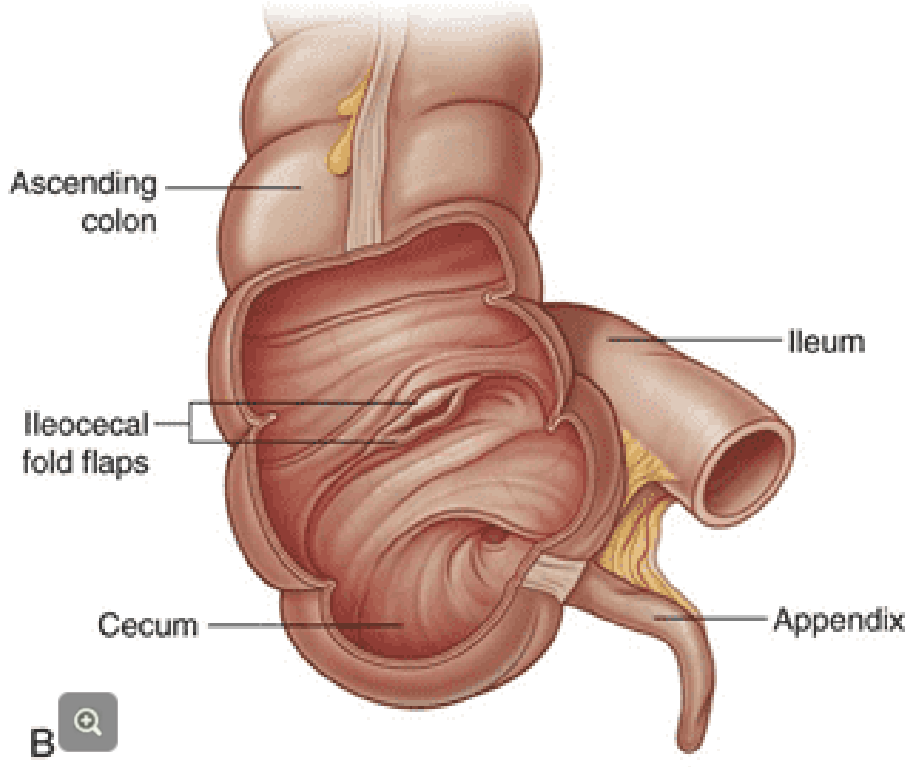
TASK

Compare the plicae circulares in the three specimens.

You might be able to notice with the naked eye that they are tallest and most tightly-packed in the jejunum. This is logical; the plicae circulares increase surface area for nutrient absorption. The majority of nutrient absorption occurs in the jejunum because of its greater surface area per unit length. Surface area is maximized in the jejunum not only because of its tall, tightly-packed plicae circulares; as explained in the eModule on the histology of the digestive tract, microscopic features that increase surface area, the **villi** and **microvilli**, are also most well-developed in the jejunum.

In the specimen of the **ileocecal junction** (right), identify the **ileocecal sphincter** by feel. Visually identify the **ileocecal fold flaps**. Identify the **cecum**, defined as **that portion of the ascending colon inferior to the ileocecal junction**. Finally, identify the **appendix**.

Moisten these specimens and cover them with a damp cloth.



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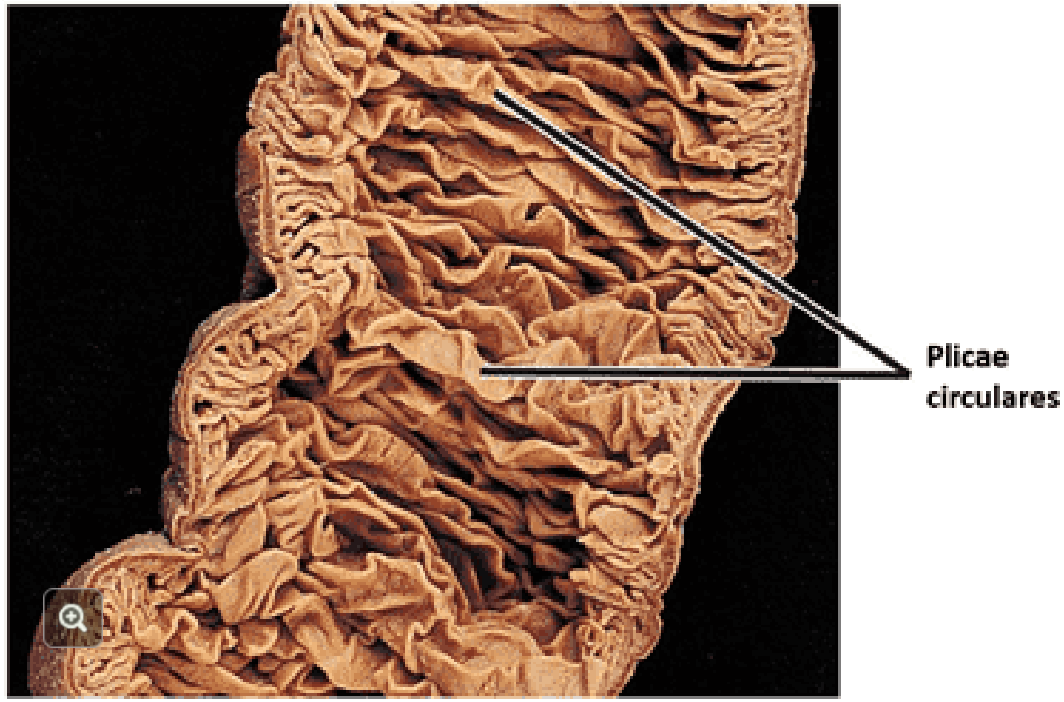
Plicae Circulares are Most Prominent in the Jejunum



The spleen is a left-sided organ lying adjacent to the 9th - 11th ribs. It is largely located between the fundus of the stomach and the diaphragm. Only when enlarged can the spleen be palpated inferior to the costal margin.

TASK

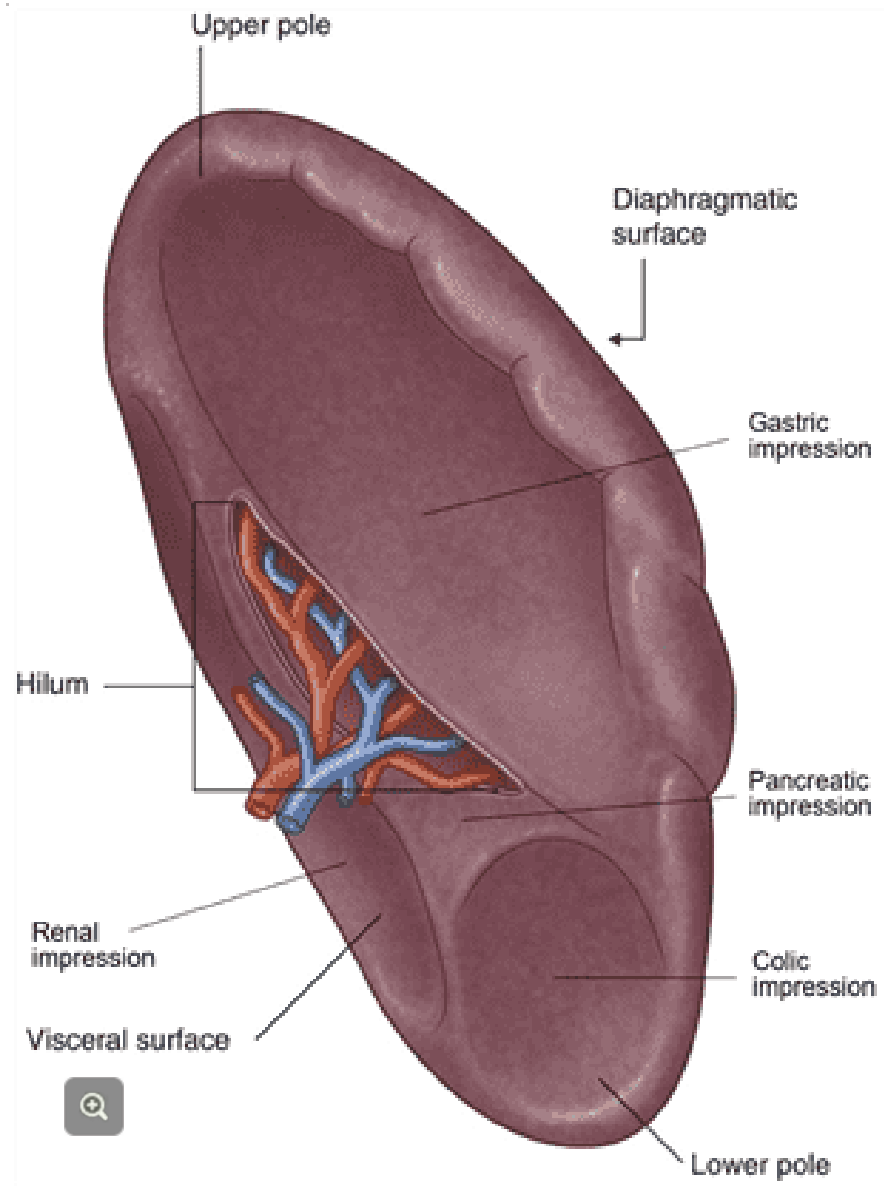
Unwrap the specimen of the spleen.

Identify its convex diaphragmatic surface, marked by costal impressions, and its irregular, concave visceral surface. Distinguish its sharp anterior border from its rounded posterior border.

On the visceral surface of the spleen, identify its hilum, containing splenic arteries and veins. Notice the contact impressions made by adjacent organs.

The gastric impression is the largest and most anterior, formed by the fundus of the stomach. The renal impression is posterior, and is made by the superior pole of the left kidney. The colic impression is formed by the left (splenic) flexure of the large intestine. The pancreatic impression is formed by the tail of the pancreas contacting its visceral surface inferior to the hilum.

Moisten the specimen and cover it with a damp cloth.



The specimen labeled **pancreas complex** consist of a pancreas, the curve of the duodenum, the spleen, the IVC with the SMV, and the aorta with the SMA.

TASK

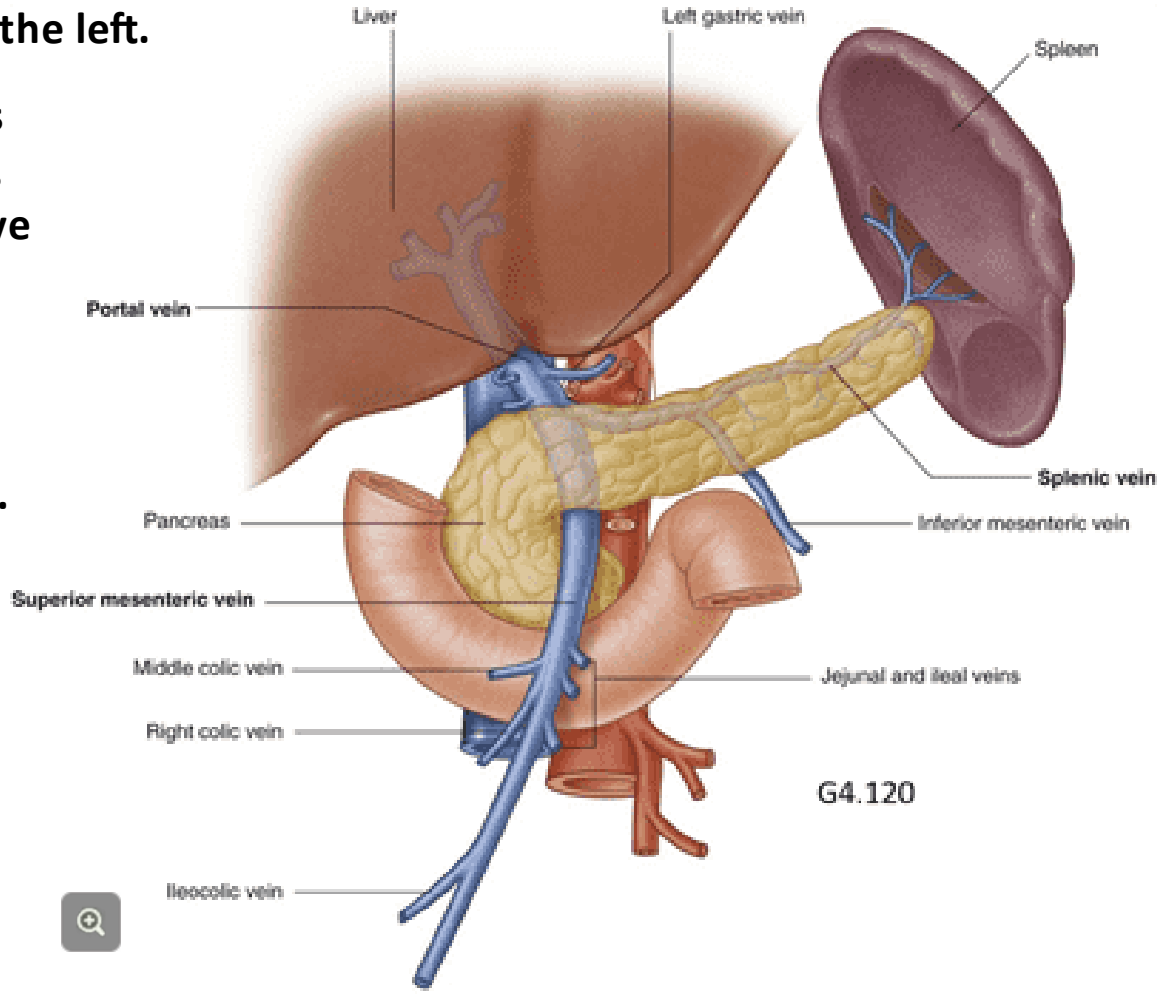
Unwrap the specimen labeled pancreas complex.

Lay it out on the table with the IVC and aorta posterior and the spleen extending to the left.

Identify the subdivisions of the pancreas, its uncinate process, head, neck, body and tail. Note the relationship of its head to the curve of the duodenum. Notice that the neck of the pancreas lies anterior to the SMV and SMA, while the uncinate process and third part of duodenum lie posterior to the SMV and SMA, and anterior to the IVC and aorta.

If the splenic artery and/or vein is present, notice their relationship to the body and tail of the pancreas. Notice the tail of the pancreas ends at the hilum of the spleen

Moisten the specimen and cover it with a damp cloth.



Since the last Progress Check, you should have identified the following structures and learned the answers to the following questions:

- gastroduodenal junction: pyloric sphincter and orifice, major duodenal papilla, plicae circulares. What are the relationships between the major duodenal papilla, the hepatopancreatic sphincter and the hepatopancreatic ampulla? What is the purpose of the plicae circulares? How does this compare to the purpose of the rugae?
- duodenojejunal junction: plicae circulares; What are two microscopic structures that also increase the surface area of the small intestine?
- ileocecal junction: plicae circulares, ileocecal valve, ileocecal folds, cecum, appendix. How is the cecum defined?
- spleen: diaphragmatic surface, visceral surface, anterior and posterior borders, hilum, contact impressions (in general). What forms the grooves on the diaphragmatic surface of the liver? Adjacent to what ribs is the spleen located? What four organs contact the visceral surface of the spleen?
- pancreas complex: uncinate process, head, neck, body and tail of the spleen; identify the parts of the duodenum present in your prosection; What part of the pancreas passes posterior to the SMV and SMA? What part of the duodenum passes posterior to the SMV and SMA? What part of the pancreas passes to the right of the SMV and SMA? What part of the pancreas passes anterior to the SMV and SMA? What parts of the pancreas are adjacent to the splenic artery and vein?

If you are satisfied with the **quality of your dissection**, and your **ability to identify these structures** and **answer these questions**, call you TA over for confirmation and for permission to clean up.