



ANATOMY OF THE LIVER

A Complete Illustrated Guide

From the whole organ to the microscopic lobule

Inside this guide

- Location, size, lobes, ligaments, and neighbors
- The eight segments, blood supply, and portal system
- Bile ducts and gallbladder, nerves, and lymphatics
- The lobule, liver cells, zones, and regeneration
- Development, variations, imaging, and biopsy
- How structure explains disease, surgery, and transplant
- 17 original diagrams, 4 labeling exercises, quiz, glossary

For patients, families, students, and community members

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Welcome

The liver is the body's largest internal organ and one of its busiest. Every minute, about a quarter of the blood pumped by your heart flows through it. In that blood the liver finds sugar to store, fats to sort, drugs and toxins to disarm, old red-cell pigment to clear, and raw materials for hundreds of proteins. It also makes bile, filters bacteria from gut blood, and can regrow after injury. All of this depends on **structure**: where the liver sits, how its blood arrives and leaves, how bile drains, and how its cells are arranged into tiny repeating units.

This guide from **The Liver and Kidney Hope Foundation (TLHF)** is a complete tour of liver anatomy: the whole organ, its lobes and segments, its unusual double blood supply, the bile ducts and gallbladder, the microscopic lobule and its cells, how the liver forms before birth, common variations, how doctors see it on imaging, and how its structure explains liver disease, surgery, and transplant. It is written in plain language for patients, families, students, and community members, and it includes 17 original labeled diagrams, tables, review questions, and four fill-in labeling exercises.

How this guide is organized

Part	Chapters
Part 1: The Big Picture	1. Why the liver matters; 2. Location, size, and shape; 3. Surfaces, lobes, and ligaments; 4. Neighbors of the liver
Part 2: Functional Anatomy	5. The eight liver segments; 6. Blood supply; 7. The portal venous system; 8. Bile ducts and gallbladder; 9. Nerves and lymphatics
Part 3: The Microscopic Liver	10. The lobule and acinus; 11. Cells of the liver; 12. Zones and metabolism; 13. Regeneration and repair
Part 4: Life Story and Variations	14. Development, growth, and aging; 15. Variations and birth differences; 16. Imaging and biopsy
Part 5: Anatomy and Disease	17. How structure explains disease; 18. Surgery and transplant anatomy; 19. Protecting your liver
Part 6: Study Tools	Labeling exercises, quiz, answer keys, anatomy by the numbers, glossary, resources

How to use it

Each chapter starts with the big idea and then adds detail. If you are new to the topic, read the boxes marked **Key point** first, then return for the tables and diagrams. Students can jump to the labeling exercises in Part 6 as a self-test.

Ranges, not rules

Sizes, flows, and percentages are typical values for healthy adults. Normal ranges vary with age, sex, body size, and the lab or imaging method. If a number here differs from your own report, ask your healthcare team what is normal **for you**.

Medical disclaimer and about TLHF

This guide is provided for **educational purposes only**. The Liver and Kidney Hope Foundation is a Nevada 501(c)(3) nonprofit organization that provides liver and kidney health education, community support, and outreach. **TLHF is not a medical provider** and does not diagnose, treat, or prescribe. Nothing in this guide replaces professional medical advice, diagnosis, or treatment. Diagrams are simplified, hand-built schematics meant for learning; they are not drawn to scale and are not a substitute for a medical atlas or for images of your own liver.

Seek emergency care (call 911 in the U.S.)

- Vomiting blood or passing black, tarry, or bloody stools
- Sudden severe pain in the upper right belly with fever, chills, or yellow skin or eyes
- New confusion, extreme sleepiness, or trouble staying awake
- Injury to the right lower chest or upper belly followed by pain, dizziness, or fainting

Words used in this guide

- **Hepatic** means "of the liver" (Greek *hepar*). A **hepatologist** is a liver doctor; a **hepatobiliary surgeon** operates on the liver, bile ducts, and pancreas.
- **Biliary** means "of bile." **Portal** refers to the portal vein, which carries blood from the gut to the liver.
- **Anterior** = front, **posterior** = back, **superior** = upward, **inferior** = downward, **medial** = toward the middle, **lateral** = toward the side.
- **Parenchyma** = the working tissue of an organ. In the liver, that means the hepatocytes (liver cells) arranged in plates.

A word from TLHF

Understanding how your liver is built is the first step to understanding liver tests, imaging, and treatment. Knowledge is not just power: it is also calming. Bring your questions to your care team, and remember that **hope is part of health**.

PART 1

The Big Picture

CHAPTER 1

Why the Liver Matters

Eight groups of jobs, one organ, and how to read anatomy

~1.5 kg weight of an adult liver (about 2 to 2.5% of body weight)	~25% of the heart's output flows through the liver each minute	500+ known functions, from making bile to clearing drugs	Regrows can restore lost volume within weeks to months
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The liver is the largest solid organ inside the body (the skin is the largest organ overall). It sits at a crossroads: nearly everything absorbed from the intestines passes through it first, and it sends its products, and its waste, out to the rest of the body and into the gut. This position explains why the liver is exposed to nutrients, medicines, alcohol, toxins, and infections, and why it has such strong defenses and such strong powers of repair.

What the liver does: more than 500 jobs in eight groups

Every job depends on how the liver is built, which is what this guide explains

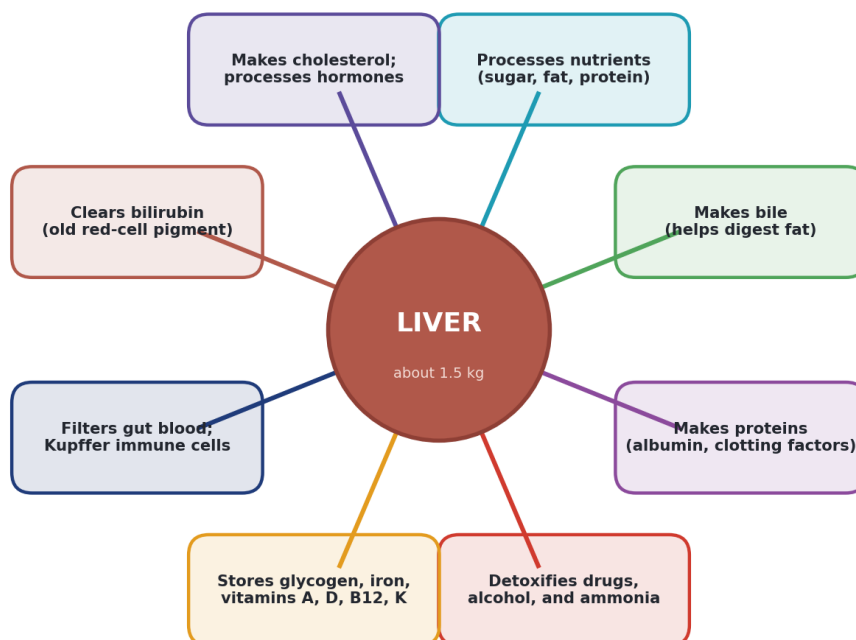


Figure 1. The eight main groups of liver functions.

Jobs of the liver and where the anatomy comes in

Job	What the liver does	Where in the anatomy it happens
Nutrient processing	Stores and releases glucose (glycogen), sorts fats, converts amino acids, makes urea from ammonia	Hepatocytes, bathed in nutrient-rich portal blood
Bile production	Makes 0.5 to 1 liter of bile daily for fat digestion and for excreting waste	Hepatocytes and bile canaliculi; bile ducts; gallbladder for storage
Protein synthesis	Albumin, most clotting factors, transport proteins, complement proteins	Hepatocytes (rough endoplasmic reticulum)
Detoxification	Chemically changes drugs, alcohol, hormones, and toxins so they can be excreted	Hepatocyte enzymes, especially in zone 3 near the central vein
Storage	Glycogen, iron (ferritin), copper, vitamins A, D, B12, and K	Hepatocytes and stellate cells
Immune filtering	Removes bacteria and debris arriving from the gut	Kupffer cells lining the sinusoids
Bilirubin clearance	Takes up bilirubin from old red cells, attaches sugar (conjugation), and excretes it in bile	Hepatocytes and bile canaliculi
Cholesterol and hormones	Makes cholesterol and lipoproteins; breaks down insulin, estrogen, and others	Hepatocytes

Key point

Structure explains function. Every feature in this guide, from the double blood supply to the one-cell-thick plates of hepatocytes, exists because it solves a problem the liver faces.

Follow the flow: a one-page map

- Blood from the intestines, spleen, and pancreas** gathers in the **portal vein**. It carries digested nutrients, and also anything the gut absorbed, such as medicines.
- Oxygen-rich blood** arrives separately through the **hepatic artery**. The two inflows meet inside the liver in the **sinusoids**, tiny blood channels between liver cells.
- As blood slows through the sinusoids, **hepatocytes** take up, change, store, and release substances, and **Kupffer cells** remove germs and debris.
- Blood leaves through the **central veins**, which join into the three **hepatic veins** and empty into the **inferior vena cava** just below the heart.
- Hepatocytes also make **bile**. It flows the opposite way, through tiny **canaliculi** into **bile ducts**, then the common bile duct to the **duodenum**. The **gallbladder** stores and concentrates bile between meals.

The language of the liver

Term	Meaning	Example
Hepat-, hepatic	Of the liver	Hepatitis: inflammation of the liver
Chole-, cholecyst-	Bile; gallbladder	Cholecystectomy: removal of the gallbladder
Porta hepatis	The "gateway" of the liver where vessels and ducts enter and leave	Portal vein, hepatic artery, and bile ducts pass through it
Glisson's capsule	Thin connective tissue coat around the liver that continues into the liver along vessels	Stretching it causes the dull right-upper ache of an enlarged liver
Sinusoid	Leaky capillary between liver-cell plates	Where blood contacts hepatocytes
Lobule / acinus	Microscopic working units of the liver	Chapters 10 and 12
-ectomy, -plasty, -ostomy	Cutting out; reshaping; making an opening	Hepatectomy, hepaticojejunostomy

CHAPTER 2

Location, Size, and Shape

Where the liver sits and what it looks like from outside

The liver is a **wedge-shaped**, soft, reddish-brown organ. It fills the upper right part of the abdomen, tucked under the right dome of the **diaphragm** (the breathing muscle) and mostly protected by the lower ribs. Its thin, tapering left portion stretches across the midline toward the left. Because it is so full of blood, it is heavy but soft and easily injured.

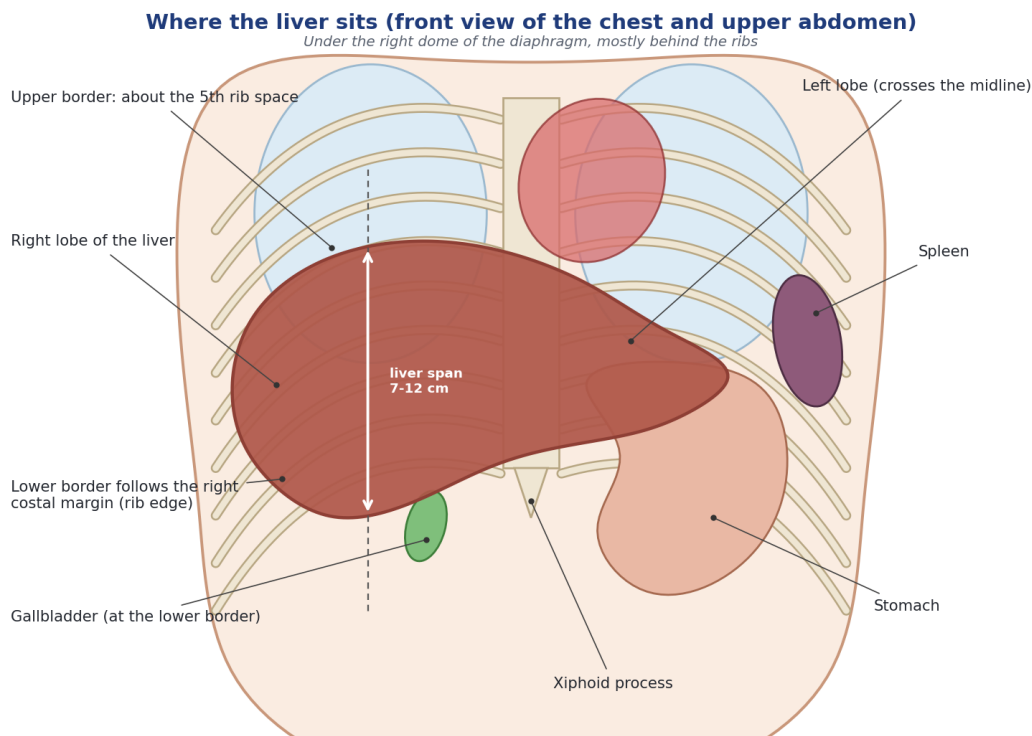


Figure 2. The liver in relation to the ribs, diaphragm, stomach, spleen, and gallbladder (front view). The arrow shows the liver span measured along the right midclavicular line.

Where exactly?

Feature	Typical position
Upper border	Reaches the 5th rib space on the right, along the midclavicular line (the line dropping from the middle of the collarbone). The right dome is higher than the left
Lower border	Follows the right costal margin (lower edge of the rib cage), then crosses the midline in the upper belly, roughly midway between the breastbone tip (xiphoid) and the navel
Vertebral levels	From about T8 to T9 (top) down to about L2 to L3 (lower border of the right lobe)
Left extent	The left lobe extends to about the left midclavicular line, in front of the stomach
Movement	Moves down 2 to 3 cm on deep breathing because it is attached to the diaphragm
Feeling it	A healthy adult liver is usually not felt below the right rib margin; the edge may be felt on a deep breath in thin people and in children. An edge felt well below the ribs can mean enlargement, but also a low-lying or lengthened right lobe (Riedel lobe)

Size and weight

Measure	Typical adult	Notes
Weight	About 1.2 to 1.6 kg (roughly 3 pounds)	Slightly less in women and smaller people; about 2 to 2.5% of body weight
Width (right to left)	About 20 to 22 cm	Widest across the right lobe
Height (top to bottom)	About 15 cm on the right	The vertical span at the midclavicular line is often reported as 7 to 12 cm on ultrasound or percussion; values differ by method and body size
Thickness (front to back)	About 10 to 13 cm	Thickest at the right lobe
Volume	About 1,200 to 1,500 mL	Measured on CT or MRI for surgery planning
Blood content	About 10 to 15% of total blood volume at any moment	The liver is a blood reservoir; it can release blood after hemorrhage

Growing with you

The liver is proportionally largest before birth and in infancy, when it makes up about 4 to 5% of body weight, twice its adult share. In infants the lower edge normally reaches slightly below the right ribs. It grows with body size through childhood and stays fairly constant in adulthood. With advanced age, liver volume and blood flow decline, on average by about 20 to 40% in very old age, although this varies widely.

The liver's feel and look

- **Color:** deep reddish brown because of its large blood content.
- **Surface:** smooth and glossy, covered by a thin capsule (Glisson's capsule) and, over most of its surface, by the peritoneum (the membrane lining the belly).

- **Consistency:** soft, spongy, and slightly firm, like a well-cooked steak; with scarring (fibrosis) it becomes firm and eventually nodular.
- **Bare area:** a patch on the back of the right lobe attached directly to the diaphragm, with no peritoneal cover (Chapter 3).

How liver size is checked

Doctors estimate liver size by **percussion** (tapping and listening for the dull note over solid organ), by **palpation** (feeling the edge), and by **imaging**. Percussion and palpation are approximate; ultrasound, CT, and MRI are more accurate.

Crowded neighborhood

The right kidney sits just behind and below the right lobe, and the gallbladder tucks against its underside. That is why gallbladder problems, liver swelling, and even right-lung or right-kidney problems can all cause pain in the same upper-right region.

CHAPTER 3

Surfaces, Lobes, and Ligaments

How the liver is divided on the outside and anchored in place

The liver has two surfaces. The smooth, domed **diaphragmatic surface** faces up and forward against the diaphragm. The flatter **visceral surface** faces down and back and touches other organs. The **inferior border** is the sharp edge between them.

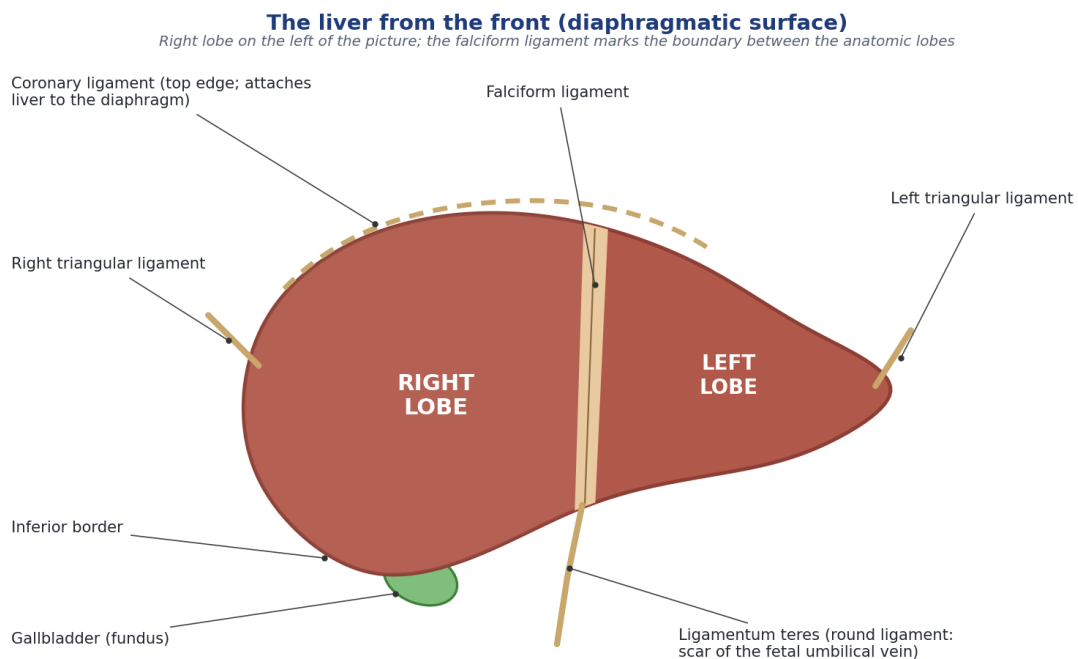


Figure 3. The liver from the front. The falciform ligament attaches the liver to the front wall of the abdomen and marks the boundary between the anatomic right and left lobes.

The four anatomic lobes

Lobe	Where it is	Notes
Right lobe	Right of the falciform ligament, the largest part (about five to six times the size of the left lobe)	Contains segments 5 to 8 (Chapter 5)
Left lobe	Left of the falciform ligament; thin, tapering tip lies in front of the stomach	Contains segments 2 to 4 in functional anatomy
Quadrato lobe	On the underside, between the gallbladder and the ligamentum teres	Is really part of segment 4b
Caudate lobe	On the underside and back, between the inferior vena cava and the ligamentum venosum	Segment 1. Has its own small veins that drain directly into the vena cava, so it often enlarges when the main hepatic veins are blocked

Two ways to divide the liver

The four **anatomic lobes** defined by surface landmarks are not the same as the **functional lobes** defined by blood supply. The true functional right and left halves are divided by a line (Cantlie's line) running from the gallbladder to the inferior vena cava, not by the falciform ligament. Surgeons plan operations by the functional anatomy.

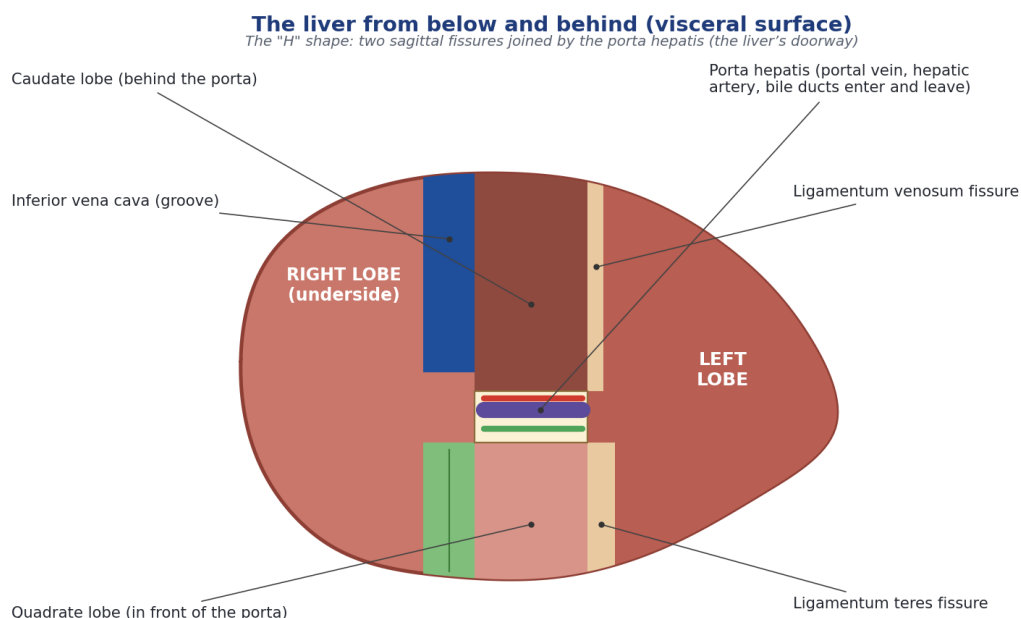


Figure 4. The liver from below and behind. The H-shaped groove pattern separates the right lobe, left lobe, quadrate lobe, and caudate lobe. The porta hepatis is the crossbar of the "H."

The H-shaped fissures on the underside

Groove	Contents	Separates
Right sagittal groove: front part	Gallbladder fossa	Right lobe from quadrate lobe
Right sagittal groove: back part	Inferior vena cava (IVC)	Right lobe from caudate lobe
Left sagittal groove: front part	Ligamentum teres (round ligament of the liver)	Left lobe from quadrate lobe
Left sagittal groove: back part	Ligamentum venosum	Left lobe from caudate lobe
Transverse groove (porta hepatis)	Portal vein, hepatic artery, right and left hepatic ducts, lymphatics, and nerves	Caudate lobe (back) from quadrate lobe (front)

Ligaments: how the liver is held in place

Ligament	What it is	Why it matters
Falciform ligament	Sickle-shaped fold of peritoneum from the front of the liver to the front abdominal wall and diaphragm	Contains the ligamentum teres along its free edge; marks the surface boundary of the right and left lobes
Ligamentum teres (round ligament)	Fibrous cord: the closed-off fetal umbilical vein	Runs from the navel to the liver; can reopen in portal hypertension (caput medusae)
Ligamentum venosum	Fibrous cord: the closed-off fetal ductus venosus	Lies in a groove between the left lobe and caudate lobe
Coronary ligaments	Upper and lower layers of peritoneum reflected between the liver and the diaphragm	Enclose the bare area; anchor the liver to the diaphragm
Right and left triangular ligaments	Points where the coronary ligament layers meet at the liver's outer tips	Cut during surgery to free (mobilize) the liver
Lesser omentum: hepatogastric and hepatoduodenal ligaments	Double layer of peritoneum from the underside of the liver to the stomach and first part of the duodenum	The free edge (hepatoduodenal ligament) contains the portal triad: hepatic artery, portal vein, and bile duct

A surgical shortcut

Behind the free edge of the hepatoduodenal ligament is the **epiploic foramen (of Winslow)**, a small opening into the lesser sac. In liver surgery, a surgeon can briefly squeeze the portal triad between finger and thumb to control bleeding. This is the **Pringle maneuver**, and it is possible because the hepatic artery, portal vein, and bile duct travel together in one bundle.

The bare area

The **bare area** is a triangular part of the diaphragmatic surface, on the back of the right lobe, where the liver is attached directly to the diaphragm and has no peritoneal covering. It lies between the upper and lower layers of the coronary ligament. Because the bare area touches the space behind the peritoneum, infection there can spread to the chest or the right kidney area, and surgeons must be careful when freeing the liver in this region.

Glisson's capsule

The liver is wrapped by a thin, fibrous **Glisson's capsule**. At the porta hepatis it continues into the liver as connective tissue sheaths around the portal vein, hepatic artery, and bile duct, dividing the liver into segments. The capsule is rich in nerve endings, whereas the liver cells themselves feel no pain. That is why liver pain is usually felt when the capsule is stretched (by swelling, blood, or a mass).

CHAPTER 4

Neighbors of the Liver

What lies against the liver and why it matters

The liver is in close contact with many organs. Its neighbors leave shallow "footprints" (impressions) on the liver's underside, and diseases in the neighbors can affect the liver and the other way around.

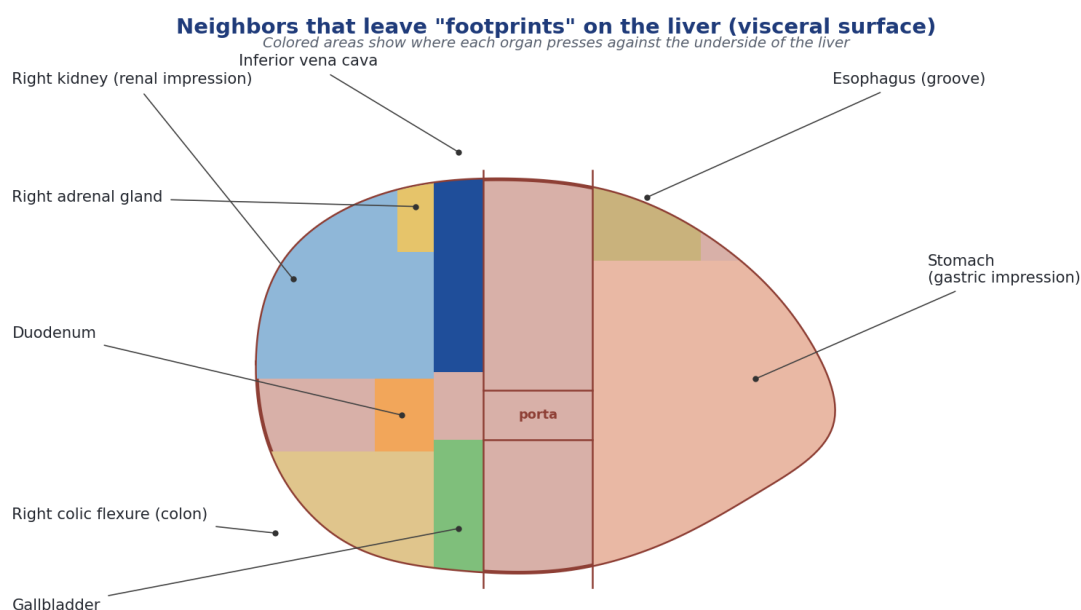


Figure 5. The areas of the visceral (under) surface of the liver in contact with neighboring organs (schematic).

What lies above, in front, behind, and beneath

Direction	Neighbor	Notes
Above	Diaphragm; right lung and pleural space; the heart (through the diaphragm)	The right dome of the diaphragm sits over the right lobe; right-lung infection or fluid may cause right-upper pain
In front	Ribs 6 to 10 and the front abdominal wall	Protects the liver; rib fractures can injure it
Behind (right lobe)	Right kidney and adrenal gland; inferior vena cava; right side of the diaphragm	The kidney presses a shallow renal impression
Beneath (right lobe)	Gallbladder, duodenum, right colic (hepatic) flexure of the colon	These leave gallbladder, duodenal, and colic impressions
Beneath (left lobe)	Stomach, and the lower end of the esophagus at the back	Gastric impression and esophageal groove
Back (medial)	Inferior vena cava, the aorta and the diaphragm's crura, the spine	The caudate lobe lies directly in front of the vena cava

Cross-section through the upper abdomen at the level of the porta hepatis

Viewed from below: the patient's right is on the left of the picture; the back of the body is at the bottom

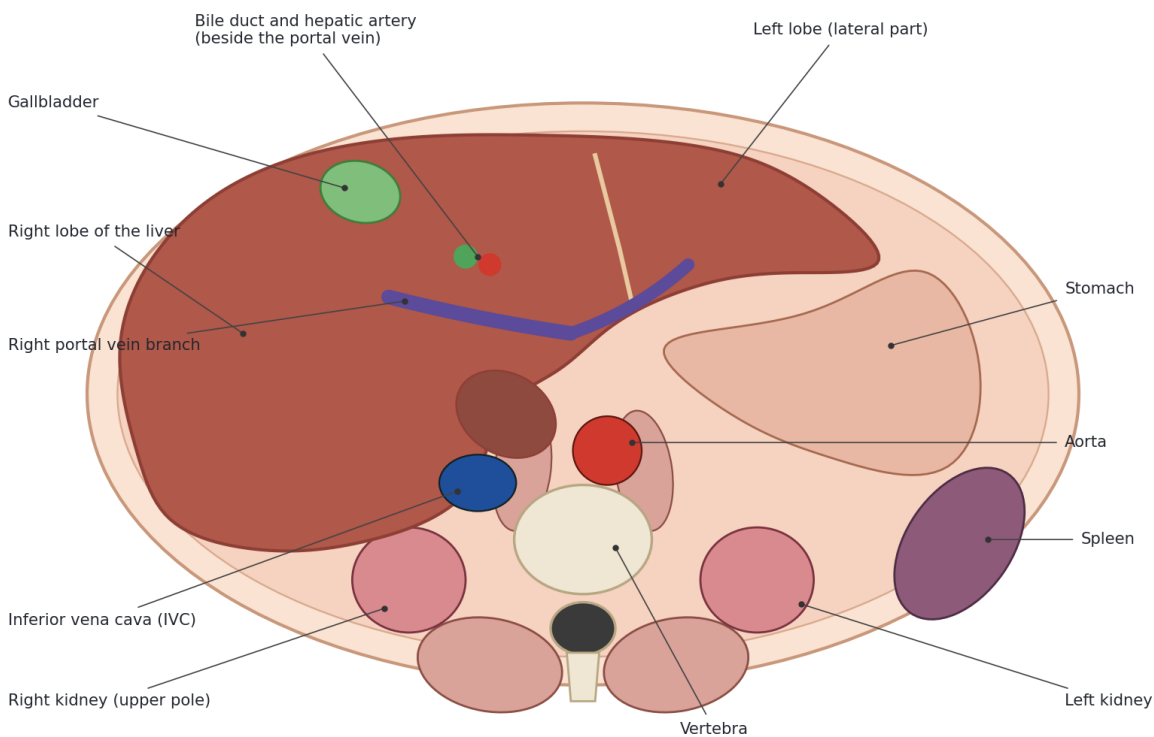


Figure 6. Schematic cross-section of the upper abdomen at the level of the porta hepatis, viewed from below.

Spaces around the liver

Peritoneal folds create potential spaces around the liver where fluid, blood, or pus can collect:

- **Subphrenic spaces** (between liver and diaphragm): abscesses can form here after abdominal infection or surgery.
- **Hepatorenal pouch (Morison's pouch)** (between the liver and right kidney): the lowest point in the upper abdomen when lying flat, so free fluid and blood collect here first. Emergency ultrasound examines this space after abdominal trauma.
- **Lesser sac** (behind the stomach and lesser omentum): reached through the epiploic foramen.

Trauma note

Injury to the right lower chest or upper abdomen can damage the liver, spleen, and right kidney at the same time. Because the liver bleeds heavily, pain, dizziness, a rapid pulse, or a swollen tender belly after injury needs emergency care.

PART 2

Functional Anatomy

CHAPTER 5

The Eight Liver Segments

How surgeons and radiologists map the liver by its blood supply

The surface lobes are a poor guide to how the liver actually works. Inside, the liver is divided into **eight functional segments**, described by the French surgeon-anatomist Claude Couinaud. Each segment has its own branch of the **portal vein and hepatic artery** entering it, its own **bile duct** leaving it, and its own **hepatic vein tributary** draining it. Because each segment is like a mini-liver, a surgeon can remove one without damaging its neighbors.

The eight Couinaud segments (front view)

Segments are numbered by their own blood supply and drainage; segment 1 (caudate lobe) lies behind and is not visible from the front

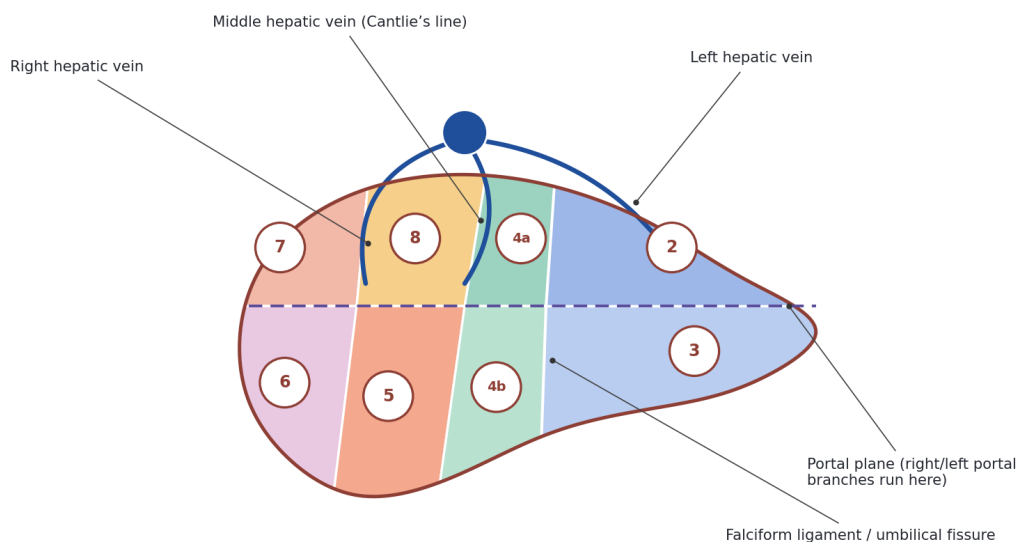


Figure 7. The eight Couinaud segments seen from the front. Dashed blue line: the portal plane. Blue tubes: the three hepatic veins converging on the inferior vena cava (IVC).

How the segments are defined

Dividing plane	What runs there	What it separates
Main portal fissure (Cantlie's line)	Middle hepatic vein; runs from the IVC to the gallbladder fossa	Functional right liver (segments 5 to 8) from functional left liver (segments 2 to 4)
Right portal fissure	Right hepatic vein	Right anterior (5, 8) from right posterior (6, 7)
Umbilical fissure	Falciform ligament and left portal vein (umbilical part)	Left medial (4) from left lateral (2, 3)
Transverse (portal) plane	Right and left portal vein branches	Upper segments (2, 4a, 7, 8) from lower segments (3, 4b, 5, 6)

The eight segments at a glance

Segment	Location	Notes
1	Caudate lobe (behind the porta hepatis, in front of the IVC)	Drains directly into the IVC; supplied by both right and left branches
2	Left lateral, upper (posterior)	Left lateral section is segments 2 and 3
3	Left lateral, lower (anterior)	Used as the graft in split and pediatric living-donor transplants
4a, 4b	Left medial section, upper (4a) and lower (4b, the quadrate lobe)	Lies between the umbilical fissure and Cantlie's line
5	Right anterior, lower	Adjacent to the gallbladder
6	Right posterior, lower	Lies near the right kidney
7	Right posterior, upper	Hard to reach surgically; sits high under the diaphragm
8	Right anterior, upper	Near the dome of the liver

Remember it

Memory trick: number the segments **clockwise as seen from the front**, starting from the caudate lobe at the back (1) and moving around the left lateral (2, 3), left medial (4), right anterior (5, 8), and right posterior (6, 7).

Why segments matter

- **Surgery:** operations are named by the segments removed: for example, **right hepatectomy** (segments 5 to 8), **left lateral sectionectomy** (segments 2 and 3), or **segmentectomy** (one segment). The blood supply and bile drainage of the remaining liver must stay intact.
- **Transplant:** living-donor liver transplants use right lobe (segments 5 to 8) grafts for adults and left lateral (segments 2 and 3) grafts for children (Chapter 18).
- **Imaging:** a lesion is reported by segment (for example, "a 2 cm lesion in segment 6") so all specialists know where to look.

- **Disease patterns:** some conditions favor particular segments; a tumor in one segment usually stays in that segment's blood supply territory for a time.

Terminology note

Newer international nomenclature (Brisbane 2000) uses terms such as **hemiliver** (right or left half), **section** (for example, right anterior section), and **segment**. The Couinaud numbers are still the common shorthand in everyday practice.

CHAPTER 6

Blood Supply

The liver's unusual double supply and its single exit

Most organs receive blood from a single artery. The liver has **two** inflows and one outflow: the **portal vein** (about 75% of the blood) and the **hepatic artery** (about 25%). Together they deliver roughly **1.5 liters per minute**, about a quarter of the cardiac output. The two supplies contribute about equally to the liver's oxygen, because portal blood has already given up some of its oxygen in the gut but still carries a lot of it.

~1.5 L/min total blood flow through the liver	~75% from the portal vein (nutrient-rich)	~25% from the hepatic artery (oxygen-rich)	~50% of the liver's oxygen from each supply, roughly
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The arterial supply

Arterial supply of the liver and gallbladder

Front view. The celiac trunk gives the common hepatic artery; the cystic artery usually comes from the right hepatic artery

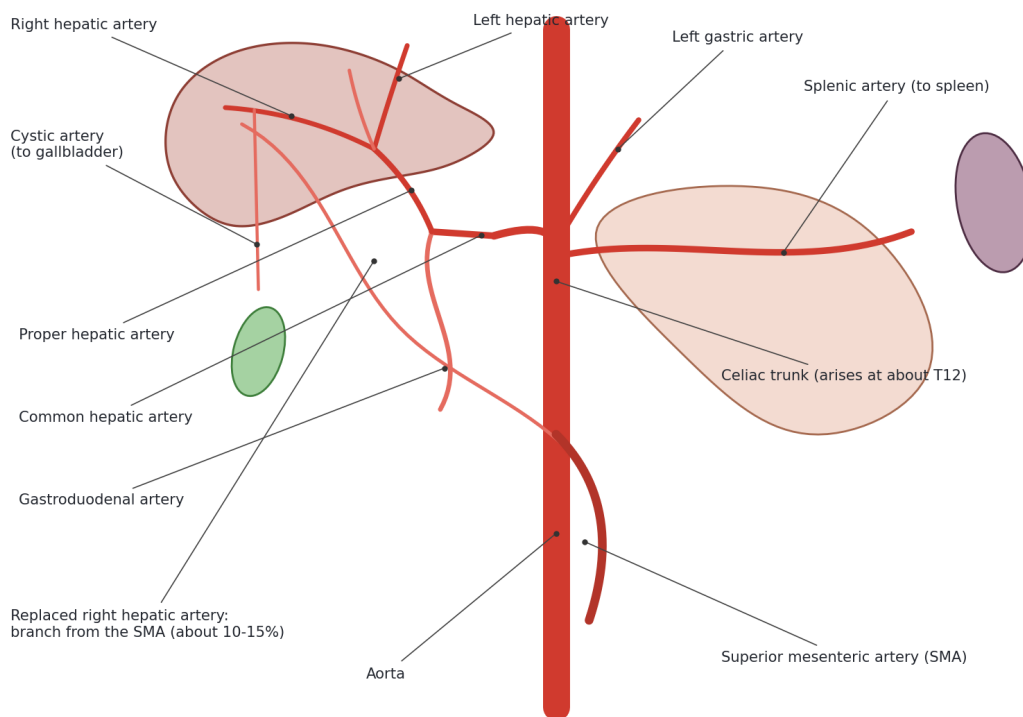


Figure 8. Arterial supply of the liver and gallbladder. The paler branch from the SMA shows a "replaced right hepatic artery" variant.

Artery	Origin and course	Notes
Celiac trunk	First main branch of the abdominal aorta below the diaphragm (about T12)	Splits into the left gastric, splenic, and common hepatic arteries
Common hepatic artery	From the celiac trunk, runs to the right along the top of the pancreas	Gives the gastroduodenal artery, then continues as the proper hepatic artery
Proper hepatic artery	Runs up in the hepatoduodenal ligament, in front of the portal vein and to the left of the bile duct	Divides into right and left hepatic arteries near the porta hepatis
Right hepatic artery	To the right lobe; usually crosses behind the common hepatic duct	Gives the cystic artery to the gallbladder
Left hepatic artery	To the left lobe; often gives a middle hepatic artery to segment 4	Supplies segments 2 to 4
Gastroduodenal artery	Runs down behind the first part of the duodenum	Supplies the stomach, duodenum, and pancreas; a landmark in liver surgery

Arterial variations

Textbook arterial anatomy is present in only about half of people. The liver's arterial supply has many variations, and knowing them prevents surgical injury:

Variation	Frequency (approximate)	Description
Typical (all from the celiac trunk)	About 55%	As described above
Replaced right hepatic artery	About 10 to 15%	The entire right lobe supply arises from the superior mesenteric artery (SMA) and runs behind the portal vein
Replaced left hepatic artery	About 10 to 15%	Left lobe supply arises from the left gastric artery and runs in the lesser omentum
Accessory arteries	About 10%	An extra artery supplies part of the liver alongside the normal ones
Other patterns	A few percent	Includes common hepatic artery from the SMA or aorta

Approximate numbers

Because the frequencies vary between studies, these numbers are only a guide. Before liver surgery, transplant, or catheter procedures, CT angiography maps each person's arteries.

The portal vein

The **portal vein** is about 8 cm long and 1.0 to 1.3 cm wide. It is formed behind the neck of the pancreas, at about the L1 to L2 level, where the **superior mesenteric vein** meets the **splenic vein**. It rises in the hepatoduodenal ligament, behind the hepatic artery and bile duct, and divides at the porta hepatis into **right** and **left branches**. It has **no valves**. Its normal pressure is low (about 5 to 10 mmHg) compared with an artery. Chapter 7 covers this system in detail.

The hepatic veins

Vein	Drains	Notes
Right hepatic vein	Right posterior and part of right anterior segments (5 to 8)	The largest hepatic vein
Middle hepatic vein	Segments 4, 5, and 8	Runs in Cantlie's line; often joins the left vein before entering the IVC
Left hepatic vein	Segments 2 and 3 (and part of 4)	Short trunk
Caudate veins and small inferior veins	Segment 1 and small parts of the right lobe	Empty directly into the IVC in the back of the liver

The hepatic veins are short, thin-walled, and enter the vena cava just below the diaphragm. They carry blood from the liver to the heart. Because they have no valves, pressure in the right side of the heart is transmitted straight back to the liver, so heart failure can make the liver swollen and congested.

Blood flow through the liver: two inflows, one outflow

Schematic. About 1.5 liters of blood pass through the liver every minute

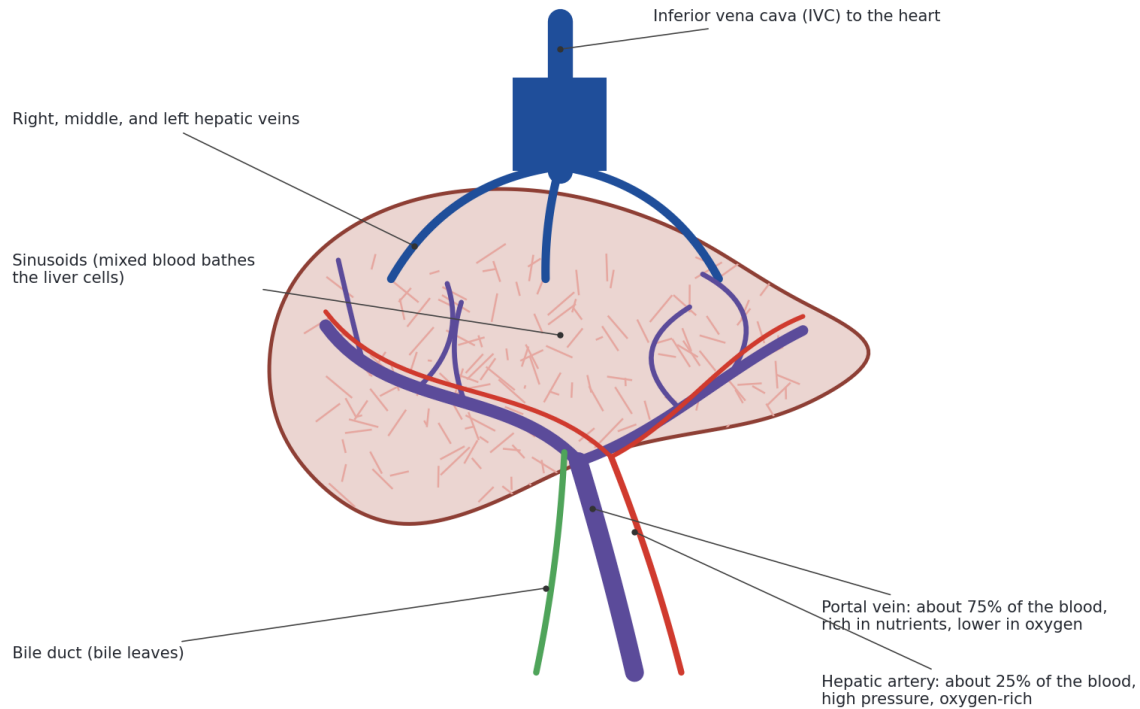


Figure 9. Blood flow through the liver: portal vein and hepatic artery bring blood in, sinusoids mix and process it, hepatic veins carry it out to the IVC, and the bile duct carries bile away.

The portal triad

Inside the liver, branches of the **hepatic artery, portal vein, and bile duct** travel together in a sleeve of connective tissue called the **portal tract**, or **portal triad** (usually also holding a lymphatic vessel and a nerve). In the microscope the triads sit at the corners of each liver lobule (Chapter 10). In contrast, hepatic vein branches travel alone, in between the portal tracts.

How the liver keeps blood flow steady

Mechanism	What happens
Hepatic arterial buffer response	When portal flow falls, the hepatic artery dilates automatically (adenosine washout) and supplies more blood, keeping total flow and oxygen delivery steady
Sinusoidal regulation	Stellate cells and endothelial cells adjust sinusoid width; nitric oxide dilates and endothelin constricts
Nervous and hormonal control	Sympathetic nerves narrow vessels during stress or bleeding, releasing blood stored in the liver into the circulation
After meals	Portal flow rises by about 30 to 100% after eating, and hepatic arterial flow falls a little

Key point

Because the liver has two blood supplies, it rarely suffers a true "infarct" (tissue death from a blocked artery) as the kidney or bowel can. That protective design is also why portal vein or hepatic vein blockages have such distinct effects. See Chapters 7 and 17.

CHAPTER 7

The Portal Venous System

The route from the gut to the liver, and the detours when it is blocked

The **portal venous system** collects blood from the digestive tract, the spleen, the pancreas, and the gallbladder and carries it through the liver before it returns to the heart. It is a "portal" system because it runs vein to capillaries (sinusoids) to vein, with no heart in between. This gives the liver first access to everything absorbed from the gut, including medicines, and lets it filter bacteria.

The portal venous system: blood from the gut to the liver

Front view, schematic. Veins from the stomach, spleen, pancreas, and intestines merge into one large vein

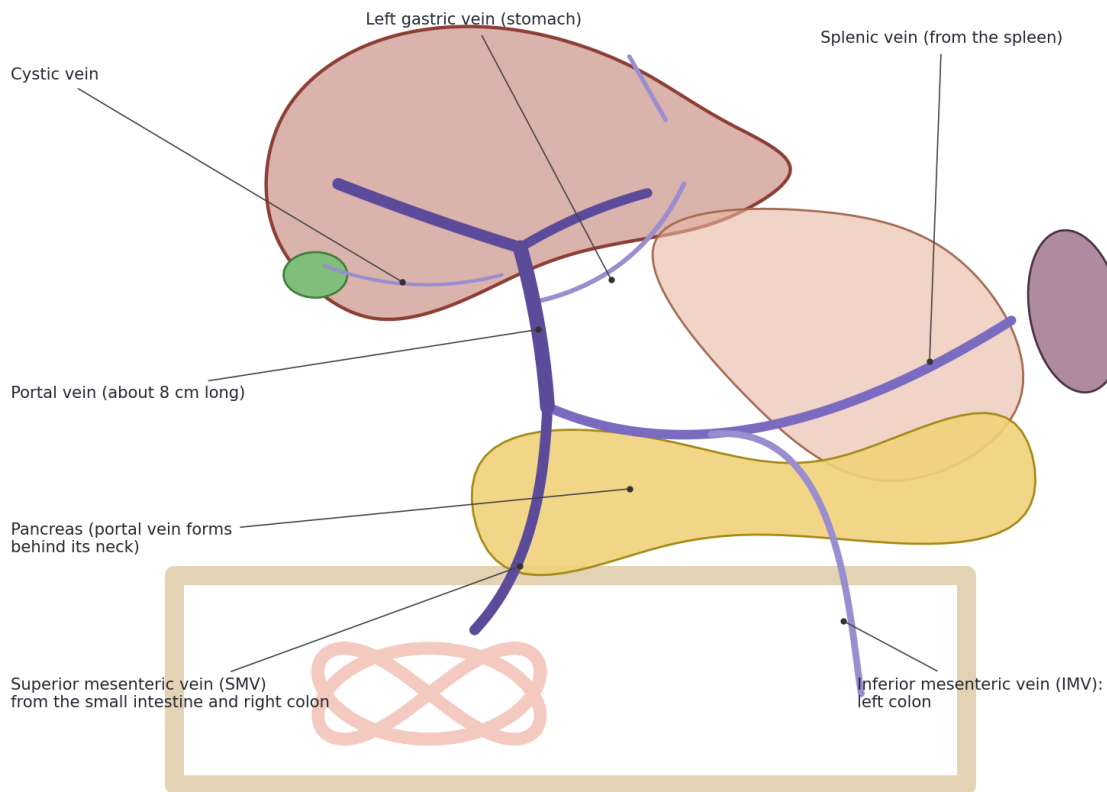


Figure 10. The portal venous system. The superior mesenteric vein and the splenic vein unite behind the pancreas to form the portal vein. The inferior mesenteric vein usually joins the splenic vein.

Tributaries and areas drained

Vein	Drains	Joins
Superior mesenteric vein (SMV)	Small intestine, right and transverse colon, part of the pancreas	Splenic vein behind the pancreatic neck to form the portal vein
Splenic vein	Spleen, stomach (short gastric veins), pancreas	Joins the SMV
Inferior mesenteric vein (IMV)	Left colon and upper rectum	Splenic vein (most commonly) or the SMV
Left and right gastric veins	Lesser curve of the stomach and lower esophagus	Portal vein directly
Cystic vein	Gallbladder	Right portal branch or portal vein
Paraumbilical veins	Small veins near the navel, running in the ligamentum teres	Left portal vein (mostly closed in adults)

Portosystemic connections: the safety-valve routes

In a few places the portal veins lie next to veins that drain into the general (systemic) circulation, joined by very small connecting veins. Normally these carry almost no flow. If the portal system becomes blocked or its pressure rises, blood is diverted through them. The swollen veins are called **collaterals**.

When the liver is scarred: portal hypertension and its side routes

Blocked portal flow finds detours (collaterals) that connect to the general venous system

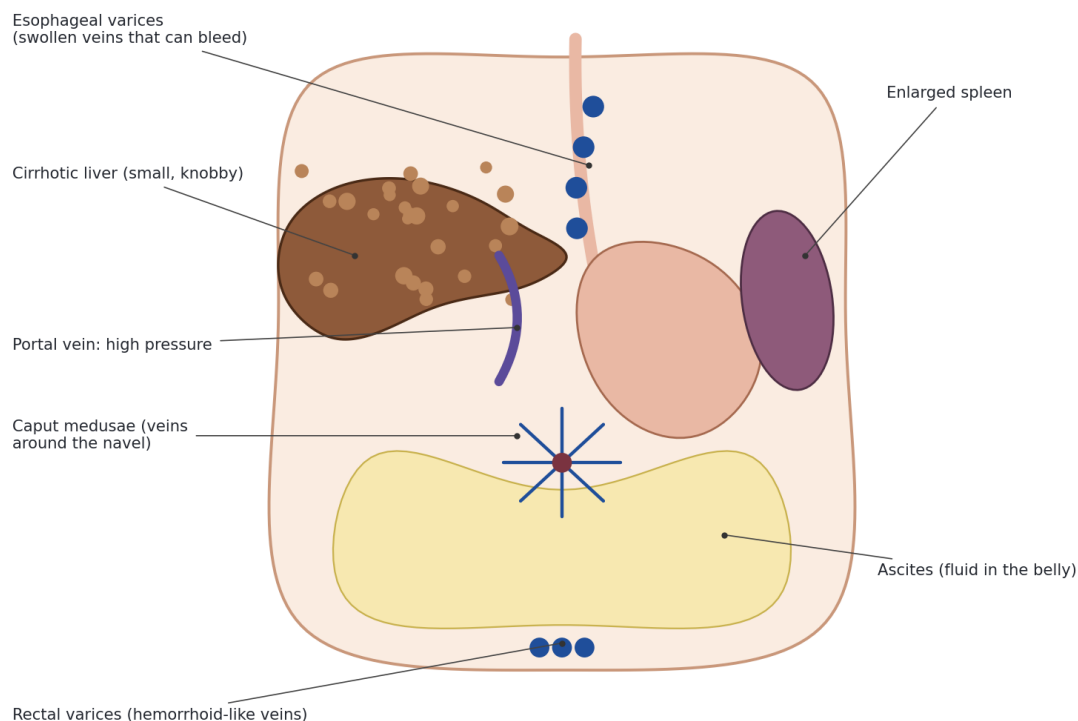


Figure 11. Portal hypertension in a person with cirrhosis. Blocked flow through the liver raises portal pressure and diverts blood through side routes (collaterals) to the general circulation.

Site	Portal side	Systemic side	What is seen when they enlarge
Lower esophagus and stomach top	Left gastric vein	Esophageal veins draining to the azygos system	Esophageal and gastric varices that can bleed dramatically
Around the navel	Paraumbilical veins	Veins of the abdominal wall (epigastric)	Caput medusae : visible veins radiating from the navel
Lower rectum and anal canal	Superior rectal vein (via the IMV)	Middle and inferior rectal veins	Rectal varices , sometimes mistaken for hemorrhoids
Behind the peritoneum	Colonic veins	Veins of the back wall of the belly, kidney, and lumbar area	Retroperitoneal collaterals, seen only on imaging
Spontaneous shunts	Splenic or portal vein	Renal vein or IVC	Large splenorenal shunts; can divert ammonia-rich blood

Portal hypertension

Portal hypertension means raised pressure in the portal system. It is measured indirectly as the **hepatic venous pressure gradient (HVPG)**: the normal value is about 1 to 5 mmHg, a value above 5 mmHg is abnormal, and values of 10 mmHg or more are considered "clinically significant" because complications such as varices become likely. By anatomical location the causes are grouped into three:

Type	Site of the block	Examples
Prehepatic (before the liver)	Portal or splenic vein	Portal vein thrombosis (clot), compression by tumor
Intrahepatic (within the liver)	Sinusoids, or the tiny veins around them	Cirrhosis (most common), schistosomiasis, some blood-vessel diseases of the liver
Posthepatic (after the liver)	Hepatic veins, IVC, or heart	Budd-Chiari syndrome, heart failure, constrictive pericarditis

Effects of portal hypertension

Effect	Anatomical reason
Enlarged spleen (splenomegaly) and low platelets	Blood backs up the splenic vein into the spleen, which traps platelets
Varices	Collateral veins are thin-walled and swell under high pressure
Ascites (fluid in the belly)	High sinusoidal pressure and low albumin push fluid out of the liver and gut surface; kidney sodium retention adds to it
Hepatic encephalopathy (confusion)	Shunted blood bypasses the liver so gut-made toxins such as ammonia reach the brain
Portal hypertensive gastropathy	Congested stomach lining veins

Treating a blocked portal system

Doctors use several anatomical approaches to lower portal pressure: medicines such as non-selective beta-blockers, endoscopic banding of varices, and a **TIPS** (transjugular intrahepatic portosystemic shunt): a stent placed through the neck vein that links a hepatic vein to a portal vein branch inside the liver, creating a controlled bypass. Treatment decisions belong to your care team.

CHAPTER 8

Bile Ducts and Gallbladder

How bile is made, drained, stored, and delivered

Bile is a yellow-green fluid made by the liver. It carries away bilirubin, cholesterol, and drug breakdown products, and its **bile acids** act like a detergent that lets fats be absorbed. Adults make roughly **500 to 1,000 mL of bile a day**. The **biliary tree** (the system of ducts) is built like a river system in reverse: many tiny streams merge into larger and larger channels that end at the duodenum.

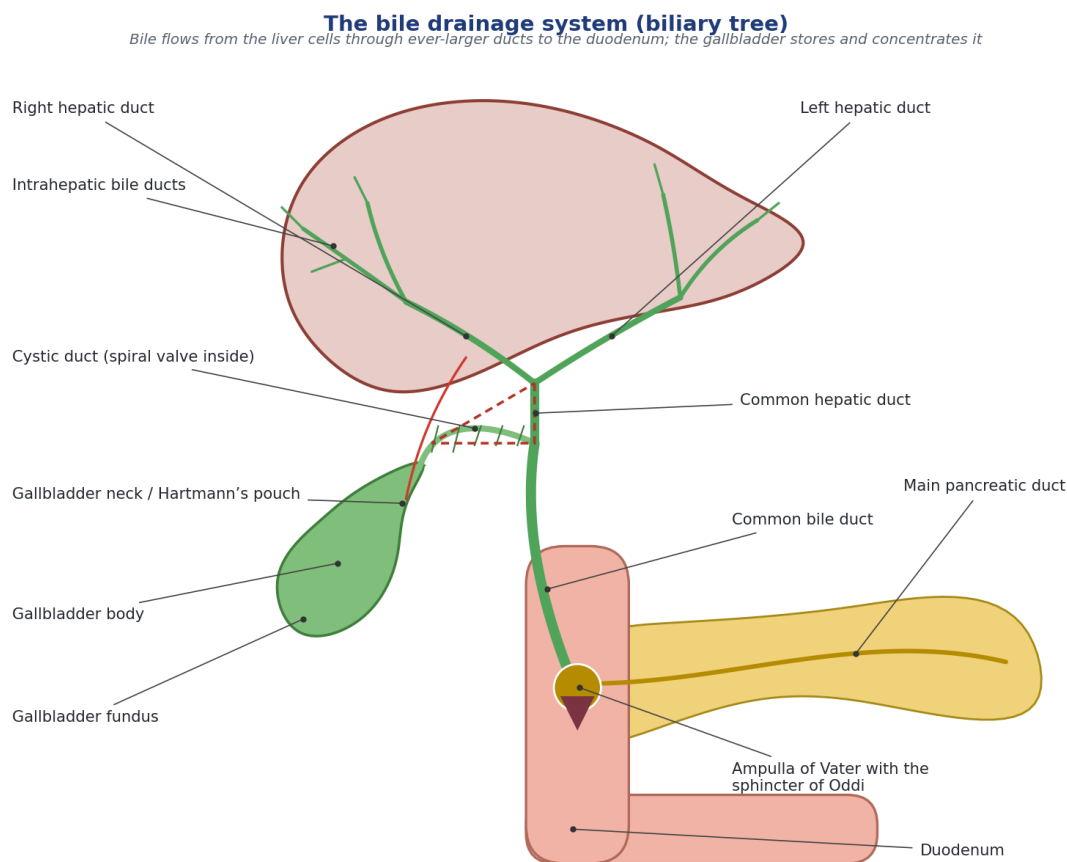


Figure 12. The biliary tree. Bile flows from small ducts inside the liver to the right and left hepatic ducts, into the common hepatic duct, and (with the cystic duct from the gallbladder) into the common bile duct. The dashed triangle is Calot's triangle.

The path bile takes

Step	Structure	Details
1	Bile canaliculi	Tiny channels (about 1 micrometer wide) formed by the walls of adjacent hepatocytes; sealed by tight junctions so bile cannot leak into the blood
2	Canals of Hering and small bile ducts	The first ducts lined by cholangiocytes (bile-duct cells); found in the portal tracts
3	Right and left hepatic ducts	Drain the right and left livers; leave the porta hepatis
4	Common hepatic duct	Formed where the right and left ducts join (the confluence); about 4 to 6 cm long
5	Common bile duct (CBD)	Formed where the cystic duct joins the common hepatic duct; about 7 to 11 cm long; normal width up to about 6 mm (wider after gallbladder removal and in older adults)
6	Ampulla of Vater and sphincter of Oddi	The CBD usually joins the main pancreatic duct at the ampulla; a muscular sphincter controls the flow into the duodenum, where the papilla opens about halfway down the C-shaped loop
7	Duodenum	Bile mixes with food and pancreatic juice here

Parts of the common bile duct

Part	Location
Supraduodenal	In the free edge of the lesser omentum, in front of the portal vein
Retroduodenal	Behind the first part of the duodenum
Pancreatic	Passes through or behind the head of the pancreas
Intraduodenal	Runs through the duodenal wall to open at the papilla

The gallbladder

The **gallbladder** is a pear-shaped sac, 7 to 10 cm long and 3 to 4 cm wide, tucked under the right lobe of the liver in the gallbladder fossa. It holds about 30 to 50 mL of bile and concentrates it 5 to 10 times by absorbing water and salts.

Part	Description
Fundus	Rounded blind end; usually just reaches the lower liver border
Body	Main storage portion
Infundibulum (Hartmann's pouch)	Bulge near the neck; a common place for stones to lodge
Neck	Narrows into the cystic duct
Cystic duct	About 2 to 4 cm long, with a spiral fold (valve of Heister) that keeps it open

Blood supply and Calot's triangle

The gallbladder is supplied by the **cystic artery**, usually a branch of the right hepatic artery, which passes through **Calot's triangle** (also called the cystohepatic triangle). This triangle is bordered by the cystic duct, the common hepatic duct, and the lower edge of the liver. During gallbladder removal, surgeons identify the cystic duct and artery here using the "critical view of safety" so the common bile duct is not injured. Because the arteries and ducts vary from person to person, this careful step is a key part of the operation.

How bile is controlled

Step	What happens
Between meals	The sphincter of Oddi is mostly closed, so bile backs up into the gallbladder, where it is stored and concentrated
A fatty meal	The duodenum releases cholecystokinin (CCK) , which makes the gallbladder contract and the sphincter of Oddi relax
After the meal	Bile acids are absorbed in the last part of the small intestine (terminal ileum) and travel back to the liver via the portal vein (enterohepatic circulation); about 95% of bile acids are reused, cycling several times per day
Without a gallbladder	Bile flows continuously into the duodenum; most people do well, and the common bile duct may widen slightly

What bile contains

Component	Approximate share or role
Water	About 95%
Bile acids and bile salts	Detergents that emulsify fats; make up most of the solids
Phospholipids (lecithin)	Help keep cholesterol dissolved
Cholesterol	Excreted in bile; can crystallize into gallstones when in excess
Bilirubin	Pigment from old red cells; gives bile and stool color
Electrolytes, drug metabolites	Balanced with bile flow; drugs and toxins leave this way

When drainage stops

A stone that blocks the common bile duct can cause jaundice, dark urine, and pale stools. If it also blocks the pancreatic duct outlet (a common channel), it can cause pancreatitis. Infection of a blocked duct (cholangitis) is an emergency. See Chapter 17.

CHAPTER 9

Nerves and Lymphatics

How the liver feels and how it drains its own fluid

Nerve supply

The liver is supplied by the **hepatic plexus**, a network of nerve fibers that follows the hepatic artery and portal vein into the liver. It contains sympathetic fibers (from spinal levels T7 to T10 through the celiac plexus), parasympathetic fibers from the vagus nerve, and sensory fibers.

Nerve type	Source	Job
Sympathetic	Spinal levels T7 to T10, celiac plexus	Narrows blood vessels; helps release glucose from glycogen during stress
Parasympathetic	Vagus nerve (through the hepatic branches)	Influences bile flow and metabolism
Sensory (pain, stretch)	Nerve endings mainly in Glisson's capsule and around portal tracts	Signal pain when the capsule is stretched
Phrenic nerve (right)	C3 to C5, supplies the diaphragm and the covering of the top of the liver	Irritation of the diaphragm surface refers pain to the right shoulder

Interesting fact

A transplanted liver has no nerve connection at all, yet it works normally. Regulation of the liver relies chiefly on blood flow, hormones (insulin, glucagon), and local chemical signals, more than on nerve commands.

Why liver-area pain shows up where it does

Where it hurts	Possible source	Typical description
Upper right belly, dull and constant	Stretch of Glisson's capsule (hepatitis, congestion, mass)	Vague fullness or ache
Right upper belly, sharp, after fatty meals	Gallbladder or bile duct	Colicky pain lasting minutes to hours; may spread to the back
Tip of the right shoulder	Irritation of the diaphragm (blood, pus, or stones near the liver)	Referred pain via the phrenic nerve (C3 to C5)
Between the shoulder blades	Gallbladder or bile duct	Aching pain from the same nerve pathways

Lymphatic drainage

The liver makes a large amount of lymph, a clear fluid that leaks from the sinusoids into the space of Disse and is collected by lymph vessels. Liver lymph is estimated to be about one quarter to one half of all lymph that enters the thoracic duct. Lymph drains in two main directions:

- **Along the portal tracts to hilar (hepatic) lymph nodes** at the porta hepatis, then to celiac nodes and the thoracic duct.
- **Along the hepatic veins** and through the diaphragm to lymph nodes in the chest (mediastinum).
- Some lymph flows across the liver surface into the peritoneal cavity; when liver pressure rises, this weeping helps produce ascites.

Key point

The portal triad, nerves, and lymphatics all travel together. If you can picture the porta hepatis as a doorway and the portal tracts as the hallways inside the liver, you can picture nearly everything that reaches or leaves the liver.

PART 3

The Microscopic Liver

CHAPTER 10

The Lobule and the Acinus

The repeating microscopic units of the liver

Under the microscope, the liver looks like a honeycomb of repeating units. There are roughly **50,000 to 100,000 lobules**, each about 1 to 2 mm across. The lobule is the classic way to picture the liver's structure; the **acinus** is a second way to describe the same tissue that better explains how the liver works and how it is injured.

The liver lobule and its zones

Left: the classic hexagonal lobule seen end-on. Right: the three metabolic zones (zone 1 near the portal tract, zone 3 near the central vein)

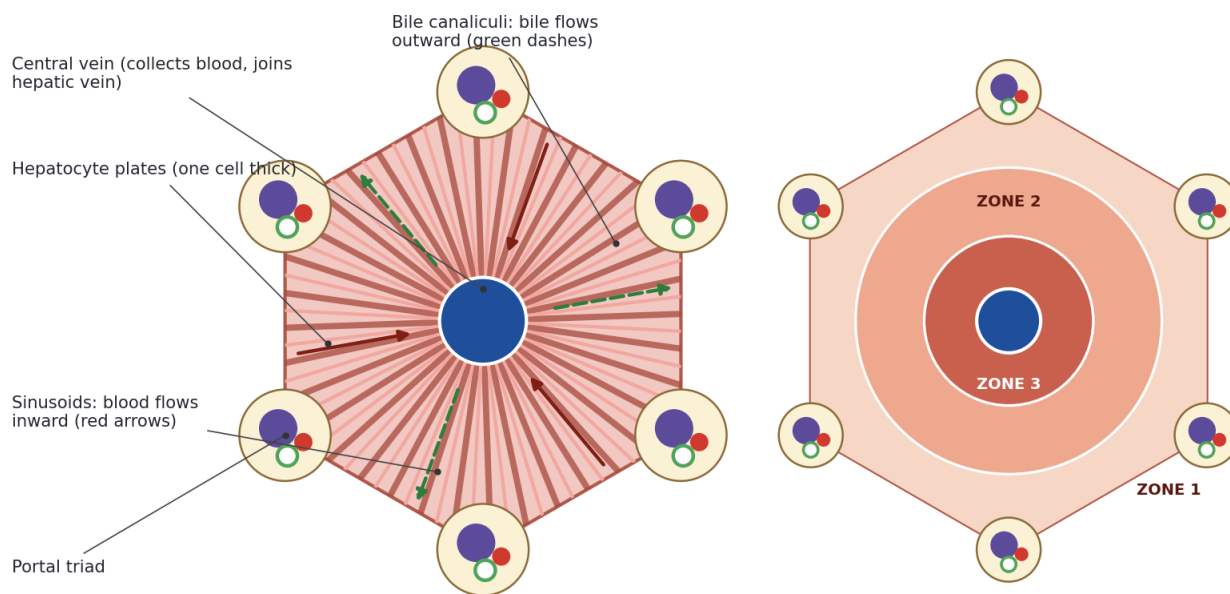


Figure 13. Left: the classic hexagonal liver lobule. Right: the same tissue divided into three metabolic zones.

The classic lobule

Part	Location	Description
Central vein	Center of the lobule	A branch of the hepatic vein (terminal hepatic venule); collects blood from the sinusoids
Hepatocyte plates	Radiate outward from the central vein like wheel spokes	Plates (cords) of liver cells, one cell thick
Sinusoids	Between the plates	Wide, leaky capillaries; blood flows from the edge toward the center
Portal tracts (triads)	At the corners of the hexagon (usually 3 to 6 per lobule)	A branch of the portal vein, hepatic artery, and a bile duct, plus lymphatics and a nerve
Limiting plate	Ring of hepatocytes bordering each portal tract	Separates the tract from the rest of the lobule; the site where "interface hepatitis" is seen
Space of Disse	Between sinusoid wall and hepatocytes	Narrow gap where plasma contacts liver cells (Chapter 11)
Bile canaliculi	Between neighboring hepatocytes inside the plates	Carry bile toward the portal tracts, opposite to blood flow

Two flows in opposite directions

	Blood	Bile
Direction	From the portal tract (edge) to the central vein (center)	From the center toward the portal tract (edge)
Channel	Sinusoids	Canaliculi, then small bile ducts
Why it matters	Cells near the portal tract meet the most oxygen and nutrients first	Bile flows away from the central vein, so injury in the center can cause bile to pool

Key point

The countercurrent arrangement (blood inward, bile outward) is the key to the liver's design: blood delivers materials to every cell, and bile carries wastes away without ever mixing with blood.

Other ways to divide the liver microscopically

Concept	Center of the unit	Shape	Best for
Classic lobule	Central vein	Hexagon, with a portal triad at each corner	Describing tissue architecture on slides
Portal lobule	Portal tract	Triangle, with a central vein at each corner	Describing bile flow (bile drains toward the tract)
Liver acinus (Rappaport)	Terminal branch of portal vein and artery	Diamond or oval between two central veins	Describing blood flow, oxygen gradient, and zone-specific injury

The three zones of the acinus

Blood entering at the portal tract has more oxygen and nutrients than blood at the end of the sinusoid. Cells are therefore divided into three zones based on distance from the incoming blood:

Zone	Position	Blood	Typical activities	More vulnerable to
Zone 1 (periportal)	Nearest the portal tract	Highest oxygen and nutrients	Making glucose from amino acids (gluconeogenesis), urea synthesis, beta-oxidation of fat, cholesterol and bile-acid handling	Toxins arriving in portal blood; early damage in some viral and cholestatic diseases
Zone 2 (mid)	Between zones 1 and 3	Intermediate	Mixed activities	Injury that spares neither end (for example, yellow fever)
Zone 3 (pericentral)	Nearest the central vein	Lowest oxygen	Drug and alcohol metabolism (high cytochrome P450 content), glutamine synthesis, fat synthesis, glycolysis	Low oxygen (shock, congestion), acetaminophen overdose, alcohol, early fatty liver in adults

Why zones matter

Zone 3 cells sit at the end of the line for oxygen, and they are also the cells with the highest drug-processing enzyme content. That combination explains why zone 3 is the most common area of injury when the liver is stressed by low blood flow or toxins.

CHAPTER 11

Cells of the Liver

Hepatocytes and their partners

The liver is made of several cell types working as a team. **Hepatocytes** (parenchymal cells) do the chemical work and make up about 80% of the volume and roughly 60 to 70% of the cell count. The remaining **non-parenchymal cells** line the blood channels and ducts, patrol for germs, and store vitamin A.

A liver sinusoid up close: how blood meets liver cells

Cross-section, not to scale. Blood flows along the top channel; bile flows the opposite way in the tiny canaliculus between cells

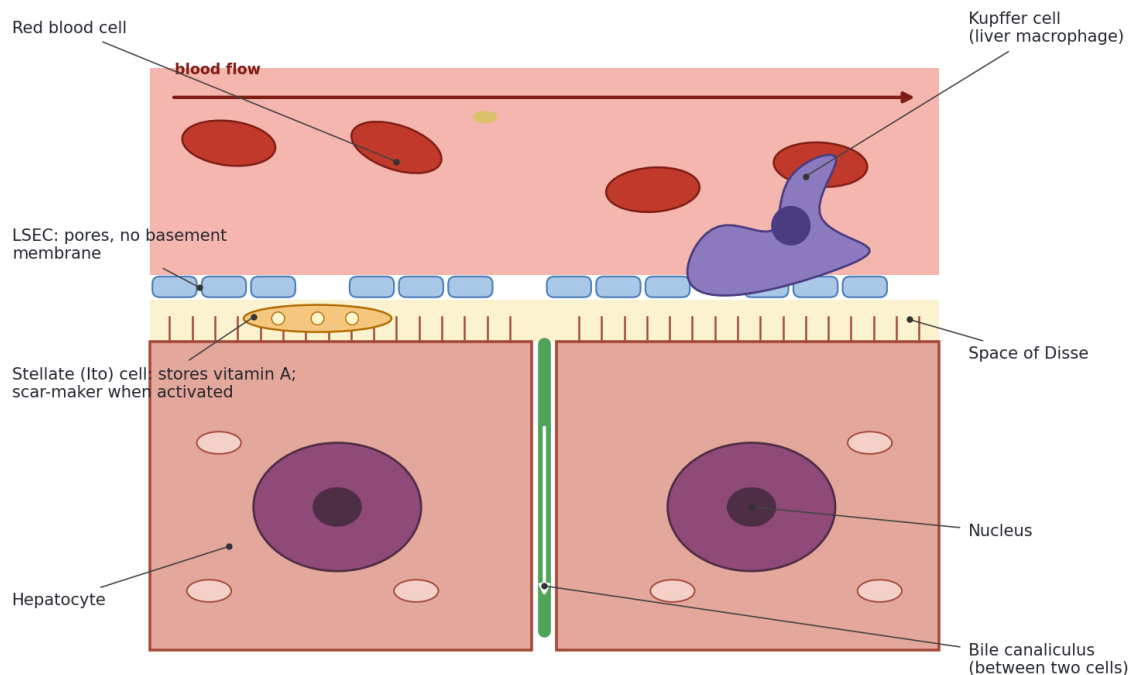


Figure 14. A sinusoid in cross-section: blood in the lumen, fenestrated endothelium, space of Disse, and two hepatocytes with a bile canaliculus between them.

The cast of characters

Cell	Share (approx.)	Where	What it does
Hepatocyte	~80% of volume; 60-70% of cells	Plates between sinusoids	Metabolism, protein and bile synthesis, detoxification, storage. Large (20 to 30 micrometers), with one or two nuclei; may live 200 to 300 days
Liver sinusoidal endothelial cell (LSEC)	~15-20% of cells	Lines the sinusoid	Flat cells with open pores (fenestrae, 100 to 150 nm) and no basement membrane, so plasma reaches hepatocytes; also clears waste molecules
Kupffer cell	~10-15% of cells	Sits inside the sinusoid, attached to the wall	Liver macrophage; engulfs bacteria, old red cells, and debris. The liver holds the largest population of tissue macrophages in the body
Hepatic stellate cell (Ito cell)	~5-8% of cells	In the space of Disse	Stores vitamin A in fat droplets in health; when injured or "activated," turns into a scar-forming cell that produces collagen (fibrosis)
Cholangiocyte	~3-5% of cells	Lines bile ducts	Adjusts bile (adds bicarbonate and water); senses flow; a source of repair cells
Pit cell (liver NK cell)	Small numbers	Sinusoid lumen	Natural killer cells that help fight viruses and tumor cells
Portal fibroblasts, immune cells	Small numbers	Portal tracts	Structural support and immune surveillance

Inside a hepatocyte

Feature	Job
Three "faces" (domains)	A sinusoidal face with microvilli toward blood; a lateral face touching neighbors, with tight junctions sealing the canaliculus; a canalicular face where bile is pumped out
Rough endoplasmic reticulum	Makes plasma proteins (albumin, clotting factors)
Smooth endoplasmic reticulum	Drug and hormone metabolism (cytochrome P450 enzymes), bile acid and cholesterol synthesis
Mitochondria (about 1,000 to 2,000 per cell)	Fat burning, energy, part of the urea cycle
Peroxisomes	Break down long-chain fats and hydrogen peroxide
Glycogen granules and lipid droplets	Stores of sugar and fat
Golgi apparatus, lysosomes	Packaging, secretion of proteins; recycling of cell parts and iron storage

The space of Disse: the exchange zone

Between the sinusoid wall and the hepatocyte lies a tiny gap, the **space of Disse** (about 0.2 to 0.5 micrometers wide). Because the endothelium has pores but **no basement membrane**, plasma flows freely into this gap and touches the hepatocyte microvilli directly. This design lets large molecules such as albumin and lipoproteins move in and out of liver cells quickly, unlike most capillaries. Stellate cells live here and also store vitamin A. Their activation is the main cause of liver scarring.

How scarring starts

When stellate cells become activated by injury from viruses, alcohol, fat, or bile blockage, they lay down collagen in the space of Disse, and the endothelial pores close ("capillarization"). The exchange between blood and liver cells becomes less efficient, and the scar tissue adds resistance to blood flow. That is the microscopic beginning of fibrosis and cirrhosis.

CHAPTER 12

Zones and Metabolism

How the liver's structure supports its chemistry

The liver is a chemical processing plant, and its structure, especially the one-way flow of blood, lets the same cell types do different jobs in different places. The table below links each major job to the anatomy behind it.

The major metabolic jobs

Area	What the liver does	Anatomical detail
Carbohydrate	After a meal, stores glucose as glycogen (holding up to about 100 g); between meals, releases glucose by breaking down glycogen and, when needed, by making new glucose (gluconeogenesis)	Portal blood brings glucose directly; zone 1 favors making glucose, zone 3 favors using it
Fats	Makes cholesterol, triglycerides, and lipoproteins (VLDL); burns fat for energy; makes ketones when fasting	Lipid droplets in hepatocytes; excess fat buildup causes fatty liver
Proteins	Makes albumin (about 10 to 15 g/day), most clotting factors, transport proteins; converts amino acids	Rough endoplasmic reticulum; secretion into the space of Disse
Ammonia and urea	Turns toxic ammonia from protein breakdown into urea for the kidney to excrete	Periportal cells make urea; perivenous cells make glutamine as a second filter
Bilirubin	Takes up bilirubin from the blood, attaches glucuronic acid (conjugation) so it is soluble, and excretes it in bile	Uptake at the sinusoidal face, excretion at the canalicular face
Drugs and toxins	Phase I (cytochrome P450, mostly in zone 3) then Phase II (conjugation) reactions make substances easier to excrete	High enzyme content in zone 3 and in the smooth endoplasmic reticulum
Vitamins and minerals	Stores vitamin A (stellate cells), vitamin D activation step, vitamin B12, K, iron, copper	Stellate cells and hepatocytes
Clotting	Makes factors I, II, V, VII, IX, X and others, and anticoagulant proteins; needs vitamin K for several of them	INR and prothrombin time reflect this synthetic function
Hormones	Breaks down insulin, sex hormones, cortisol; makes angiotensinogen, IGF-1, thrombopoietin	Hepatocytes
Immunity	Filters gut bacteria (Kupffer cells); makes complement and acute-phase proteins	Kupffer cells in sinusoids

How liver tests relate to anatomy

Blood test	What it mostly reflects	Anatomical clue
ALT (alanine aminotransferase)	Injury to hepatocytes	Found mainly inside liver cells; leaks into the blood when the membrane is damaged
AST (aspartate aminotransferase)	Injury to liver (and muscle, heart)	Also in mitochondria; ratios help distinguish causes
ALP (alkaline phosphatase) and GGT	Bile duct injury or blockage (ALP also rises with bone disease)	Made by cholangiocytes and canalicular membranes
Bilirubin (total, direct)	Bile flow and the liver's ability to process bilirubin	Direct (conjugated) rises with blocked bile flow
Albumin, INR (PT)	The liver's synthetic function	Fall or rise slowly; more sensitive to loss of functioning tissue
Platelets	An indirect clue to portal hypertension	A large spleen traps platelets

Function vs injury

Liver tests are called "liver function tests," but only albumin, INR, and bilirubin truly reflect function. ALT, AST, ALP, and GGT mainly show **injury**. A person can have normal blood tests and still have significant liver disease, and abnormal tests do not always mean disease. Interpretation belongs to your care team.

CHAPTER 13

Regeneration and Repair

The organ that can regrow

The liver is the only internal organ that can regrow a large portion of itself. This ability comes from its cellular structure and is the basis for **living-donor transplant** (Chapter 18). Understanding regeneration also explains why long-term injury eventually overcomes this capacity.

How regeneration works

Stage	What happens	Timeline (approximate)
Priming	After tissue is lost, blood flow through the remnant rises; Kupffer cells release signals (IL-6, TNF); hepatocytes "wake up"	Hours
Proliferation	Normally quiet hepatocytes re-enter the cell cycle and divide, followed by bile-duct cells, stellate cells, and endothelium	Peak within 1 to 3 days in animal studies; volume mostly restored within weeks
Termination	Growth stops when the liver reaches the size the body needs; stellate cells and matrix rebuild architecture	Weeks to a few months
Backup routes	When hepatocytes are badly damaged, progenitor cells near the canals of Hering can make new hepatocytes and cholangiocytes	Slower

Limits of regeneration

- **Size:** a healthy liver can regrow after removal of up to about two-thirds of its volume, but it needs enough remnant to keep the person alive during regrowth. Commonly used guides are about 20 to 30% of liver volume in a healthy liver and 40% or more in a scarred or diseased one.
- **Architecture:** regrowth restores mass better than perfect structure; repeated injury can create nodules without normal vessels.
- **Age and disease:** regeneration is slower in older adults, with fatty liver, and with cirrhosis.
- **Chronic injury:** when injury is continuous (for example, viral hepatitis or alcohol), scar tissue accumulates faster than the liver can repair, and fibrosis progresses.

From healthy liver to cirrhosis: how the microscopic architecture changes

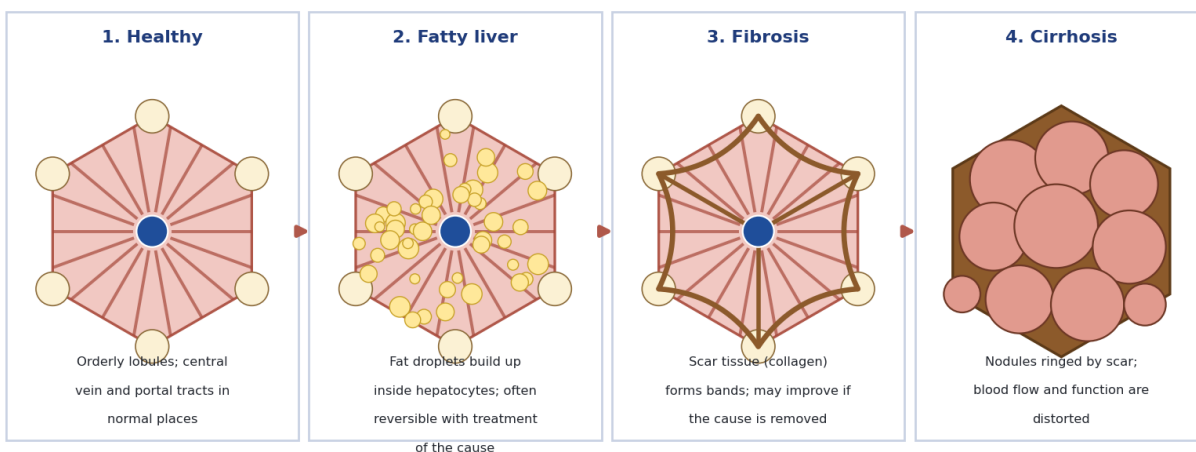


Figure 15. Stages of chronic liver injury seen at the microscopic level: healthy lobules, fat buildup, scar bands (fibrosis), and cirrhosis.

From injury to scar: the fibrosis staging idea

Stage (METAVIR-like)	Meaning	Notes
F0	No fibrosis	Normal architecture
F1	Mild scarring around portal tracts	Often silent
F2	Scar extends beyond the portal tracts	Considered "significant" fibrosis
F3	Bridges of scar link portal tracts and central veins	"Advanced" fibrosis
F4	Cirrhosis: regenerative nodules surrounded by scar	Architecture permanently altered, but stable disease can be managed for many years

Key point

Removing the cause of injury (for example, curing hepatitis C, controlling hepatitis B, stopping alcohol, or losing weight in fatty liver disease) allows scar tissue to stop growing and sometimes to shrink. Early stages can improve substantially. That is one reason early detection matters, and why the liver's power to regrow is such a source of hope.

Different measures, one process

Stage scales (F0 to F4), imaging stiffness scores, and blood-test scores all approximate the same process. Your care team uses them along with your history to guide decisions. Ask which measure they use and what it means for you.

PART 4

Life Story and Variations

CHAPTER 14

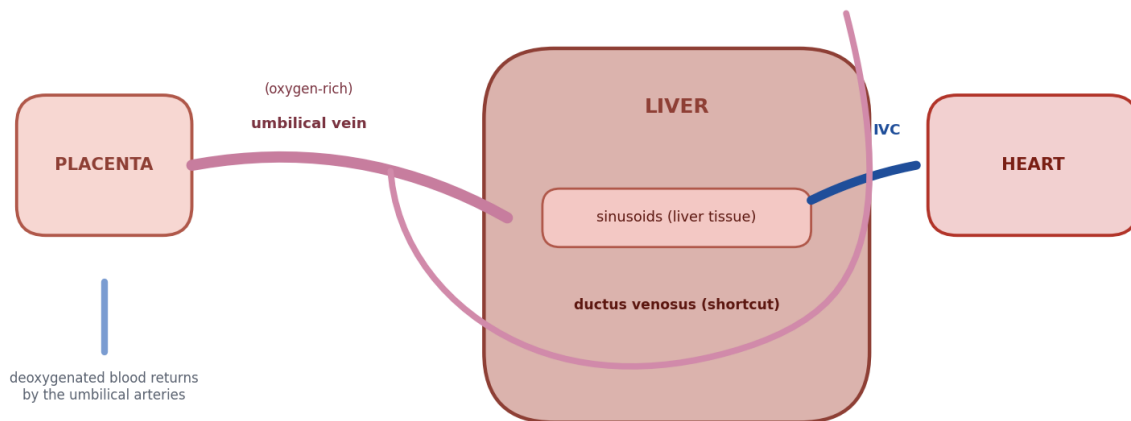
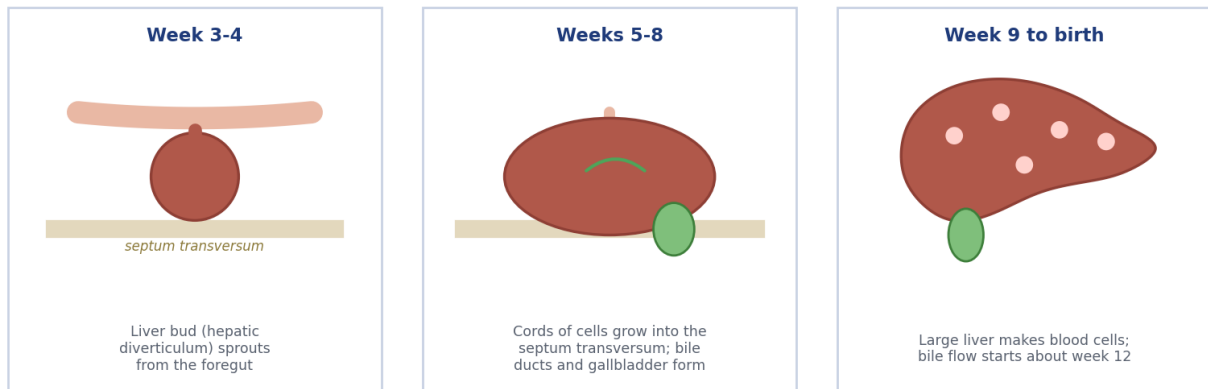
Development, Growth, and Aging

From a bud in the embryo to a lifetime organ

The liver begins to form remarkably early, in the third to fourth week of pregnancy, and by the end of the first trimester it is already the largest organ in the fetus's belly. In the fetus, the liver is a blood-forming organ and a gate through which oxygen-rich blood from the placenta flows.

How the liver forms and how blood flows through it before birth

Top: three stages of liver development. Bottom: fetal circulation (the ductus venosus lets much blood bypass the liver)



After birth: umbilical vein > ligamentum teres (round ligament); ductus venosus > ligamentum venosum

Figure 16. Top: stages of liver development. Bottom: fetal circulation through the liver, with the ductus venosus shortcut. After birth the umbilical vein and ductus venosus close and become ligaments.

Key steps and timeline

When	Event
Weeks 3 to 4	The hepatic diverticulum (liver bud) sprouts from the endoderm of the foregut, near what will become the duodenum
Weeks 4 to 6	Cords of liver cells (hepatoblasts) invade the septum transversum (a sheet of tissue near the heart) and mix with blood vessels that will become sinusoids; the bud divides into a larger cranial part (liver and intrahepatic ducts) and a smaller caudal part (gallbladder and cystic duct)
Weeks 6 to 7	Blood-forming cells settle in the liver, which becomes the main site of blood cell production until late in pregnancy
About week 10	Liver is roughly 10% of the body weight at this stage; it fills much of the abdomen
About week 12	Bile production begins; bile enters the gut and gives the first stool (meconium) its dark green color
Late pregnancy	Blood production shifts to bone marrow; liver enzymes for bilirubin and drug metabolism mature slowly, mostly after birth
Birth	The umbilical vein and ductus venosus close over days to weeks and become the ligamentum teres and ligamentum venosum

Fetal circulation and the liver

Oxygen-rich blood returns from the placenta through the **umbilical vein**. It enters the liver at the front (the future ligamentum teres). Some of the blood flows through the liver sinusoids, and a variable share (roughly 20 to 50%) is diverted through the **ductus venosus**, a channel that runs straight through the liver to the inferior vena cava. The fetal liver does not need to do the work of the gut and detoxification, because the placenta handles waste exchange. After birth, when the umbilical cord is clamped and the baby starts to breathe, these channels close.

Fetal structure	After birth becomes	Where
Umbilical vein	Ligamentum teres (round ligament)	Free edge of the falciform ligament
Ductus venosus	Ligamentum venosum	Groove between the left lobe and caudate lobe
Umbilical arteries	Medial umbilical ligaments	Sides of the bladder to the navel

Before and after birth

Newborn jaundice is common. In the first days the baby's liver is still maturing the enzyme (UGT1A1) that conjugates bilirubin, while newborn red cells break down quickly. This "physiologic jaundice" typically peaks at about 3 to 5 days. Jaundice that starts in the first 24 hours, lasts beyond two weeks, or comes with pale stools or dark urine needs medical evaluation.

The liver across the lifespan

Life stage	Changes
Newborn and infant	Liver is relatively large (about 4 to 5% of body weight); the lower edge may extend below the ribs; enzymes for drug metabolism are still maturing, which is why drug doses in infants are adjusted
Childhood	Liver grows in proportion to body size; drug-metabolizing enzymes reach adult levels in the first years
Adulthood	Stable size and function; regenerative capacity is high
Pregnancy	Liver size stays about the same, but blood flow changes; the enlarged uterus shifts the liver upward; some albumin and clotting values change normally
Older age	Liver volume and blood flow decline (about 20 to 40% in very old age); fewer, larger hepatocytes; slower regeneration; reduced clearance of some drugs, so dose adjustments are common

Aging vs disease

Fatty liver disease, diabetes, obesity, and heavy alcohol use are not a normal part of aging. A change in liver tests or a new lump or swelling in the upper right belly deserves evaluation at any age.

CHAPTER 15

Variations and Birth Differences

When the plan for building the liver changes

Every liver differs a little from the textbook. Most variations are harmless and are found only on imaging or during surgery; a few cause disease. Knowing the common variations helps surgeons avoid injury and helps radiologists explain unusual findings. The frequencies below are approximate.

Common variations of the liver and its vessels and ducts

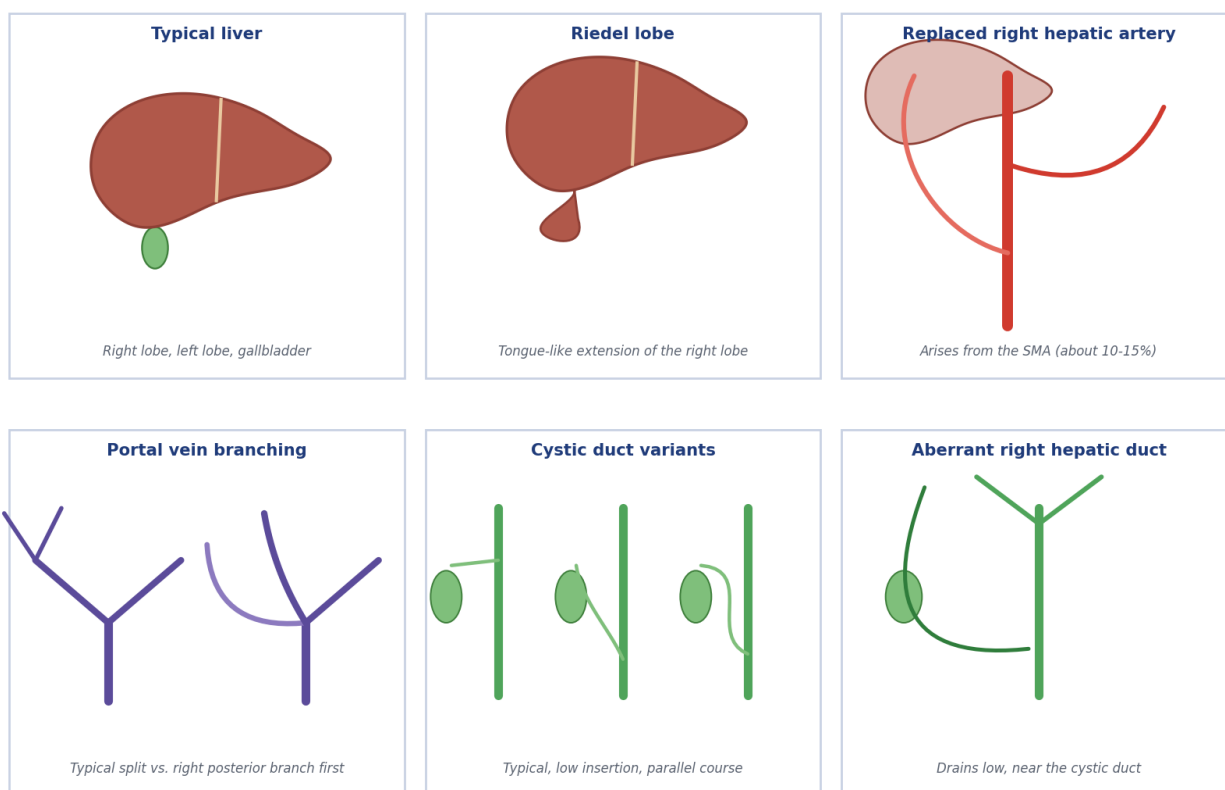


Figure 17. Common variations of the liver, its arteries, portal branches, and bile ducts (schematic).

Common anatomic variations

Variation	Approximate frequency	Description	Why it matters
Riedel lobe	A few percent; more common in women	Tongue-like downward extension of the right lobe (often segment 6)	Can be felt below the ribs and mistaken for an enlarged liver or a mass
Accessory lobes and fissures	Uncommon	Extra small lobes or deep grooves in the liver surface	May be mistaken for a tumor on imaging; surgical planning
Replaced or accessory hepatic arteries	About 40 to 45% have some arterial variation	Right lobe supplied from the SMA, left lobe from the left gastric artery, or extra arteries	Risk of injury during pancreatic, liver, or bile duct surgery; important in transplant
Portal vein branching variations	About 20 to 25%	Trifurcation instead of two branches; right posterior branch arising first	Affects planning for right lobe living donation and resections
Hepatic vein variations	Common	Additional inferior right hepatic veins; joined middle and left veins	Important for drainage of a graft in transplant
Cystic duct variations	About 15 to 20%	Low insertion into the common hepatic duct, parallel course, spiral around the duct	Increases risk of bile duct injury in gallbladder surgery
Aberrant or accessory bile ducts	About 10 to 20%	A right posterior duct that enters the common hepatic or cystic duct low, or into the gallbladder	A small duct can be injured or leak after surgery
Agenesis or hypoplasia of a lobe	Rare	A lobe or segment fails to develop; the other lobe enlarges	Often found by chance

Birth differences that affect the liver and bile ducts

Condition	Approximate frequency	What it is	Key point
Biliary atresia	About 1 in 8,000 to 18,000 births	Bile ducts outside (and often inside) the liver are inflamed and scarred shut soon after birth	Causes persistent jaundice and pale stools; early surgery (Kasai portoenterostomy) improves outcomes
Choledochal cyst	About 1 in 100,000 to 150,000 in the West; more common in East Asia	Cystic widening of the bile duct	Risk of infection, stones, pancreatitis, and later duct cancer; surgical removal
Alagille syndrome	About 1 in 30,000 to 50,000	Inherited condition with too few bile ducts in the liver, plus heart, spine, and face features	Chronic cholestasis; managed by specialists
Congenital hepatic fibrosis and Caroli disease	Rare	Abnormal bile-duct plate formation causing fibrosis or duct dilation	Portal hypertension may develop; often linked to inherited kidney cyst disease
Polycystic liver disease	Common in people with polycystic kidney disease	Multiple fluid-filled cysts in the liver	Usually symptom-free; large cysts can cause pressure symptoms
Situs inversus	About 1 in 10,000	Organs mirror-imaged: the liver sits on the left	Usually no health problem, but crucial information for surgeons
Congenital portosystemic shunt	Rare	An abnormal vein connects the portal system directly to the vena cava	Toxins bypass the liver; can cause confusion or growth problems
Inherited metabolic conditions	Varied	Examples: Wilson disease, alpha-1 antitrypsin deficiency, hemochromatosis	Liver cells store too much copper, abnormal protein, or iron

Do not panic about "incidental" findings

Many liver variations are discovered incidentally during a CT scan, MRI, or ultrasound done for another reason. An unusual-looking finding is often a normal variant, but new findings should always be reviewed by the doctor who ordered the test.

CHAPTER 16

Seeing the Liver: Imaging and Biopsy

What each test shows about anatomy

Imaging lets doctors see the liver's size, shape, blood vessels, ducts, and texture. Each test highlights different features. Images are described using the **Couinaud segments** and standard planes, so the report can say exactly where something is.

Test	How it works	What it shows well	Considerations
Ultrasound	Sound waves; no radiation; often the first test	Size, surface, brightness (fat), gallstones, bile-duct width, portal vein flow (Doppler), fluid, large masses	Depends on body size and bowel gas; safe in pregnancy and children
Elastography (FibroScan, shear-wave, MR elastography)	Measures how stiff the liver is using vibration or ultrasound	Estimates the amount of scarring (fibrosis) without a biopsy	Results are affected by fasting, inflammation, and congestion; interpreted with other tests
CT scan	X-ray slices, usually with contrast dye	Liver shape, blood vessels (arteries, portal and hepatic veins), masses, injuries, abscess	Uses radiation; contrast needs attention to kidney function; multiple timed phases show how a lesion fills with blood
MRI and MRCP	Magnets and radio waves; MRCP outlines bile ducts	Fat and iron content, subtle masses, bile ducts and pancreatic duct without a scope	No radiation; long scan; contrast agents are chosen with kidney function in mind
HIDA scan (hepatobiliary scintigraphy)	Injected tracer taken up by liver cells and excreted in bile	Bile flow and gallbladder emptying	Low radiation; shows function more than fine detail
ERCP	Scope through the mouth to the duodenum; dye injected into the ducts	Bile and pancreatic ducts; allows stone removal and stents	Invasive; risk of pancreatitis; used for treatment more than diagnosis
Angiography	Contrast injected into arteries or veins	Hepatic artery, portal and hepatic vein anatomy; used for treatments (embolization, TIPS)	Invasive; often combined with treatment
Liver biopsy	A thin needle takes a tiny core of tissue, through the skin (usually right side, between ribs) or through the neck vein (transjugular) when clotting is a problem	Microscopic structure: inflammation, fat, scar, iron, bile-duct injury, tumors	The sample is about 1/50,000 of the liver; usually at least 15 to 20 mm long with 10 or more portal tracts is preferred; bleeding risk is checked first

What a normal liver looks like on ultrasound

- **Size:** typically a right-lobe span of about 15 cm or less in the midclavicular line on ultrasound (values vary with method and body size); smooth, sharp edges.
- **Echo texture:** uniform, slightly brighter than the normal right kidney cortex. A bright liver ("hyperechoic") suggests fat buildup.
- **Portal vein:** up to about 13 mm wide; flow toward the liver (hepatopetal) on Doppler; reversed flow is a sign of advanced portal hypertension.
- **Hepatic veins:** thin-walled channels that converge toward the vena cava; normal waveforms show pulsing with the heartbeat.
- **Bile ducts:** the common bile duct is normally up to about 6 mm wide; the small intrahepatic ducts are barely visible.
- **Gallbladder:** thin-walled and free of stones or sludge; usually best seen after fasting.

Reading a CT or MRI cross-section

- The right lobe fills the left of the picture, the left lobe crosses in front of the aorta and stomach (see Figure 6).
- On contrast CT, the **hepatic artery** lights up first (arterial phase), then the **portal vein** (portal phase), then the **hepatic veins**; abnormal lesions often stand out in a specific phase.
- **Fat** makes the liver darker on CT than the spleen; **iron** makes it darker on MRI.
- A nodular surface, a large caudate lobe, and a small right lobe can suggest cirrhosis; the spleen may be enlarged and collateral veins may be visible.

Reading a report

When you receive a radiology report, look for the words **steatosis** (fat), **hepatomegaly** (enlarged liver), **cirrhotic morphology**, **lesion** (any abnormal spot), **cyst** (usually harmless if simple), **hemangioma** (a common benign blood-vessel lesion), and **LI-RADS** (a scoring system for lesions in high-risk livers). Ask your healthcare team what each means for you.

Normal variants

Common harmless findings include simple cysts, small hemangiomas, areas of focal fat or focal fat sparing near the gallbladder, and normal variants such as a Riedel lobe. Radiologists are used to these, but new findings should always be reviewed by your doctor.

PART 5

Anatomy and Disease

CHAPTER 17

How Structure Explains Disease

Using anatomy to understand symptoms, tests, and treatments

Every liver disease affects one or more parts of the anatomy you have just learned. Knowing **which part** is affected explains which tests are ordered and why treatments differ. This chapter connects structure to disease. It is an overview for understanding, not a diagnostic guide.

Disease by location

Anatomic level	Problem examples	Typical clues
Hepatocytes	Viral hepatitis (A, B, C, E), alcohol-related liver disease, metabolic dysfunction-associated steatotic liver disease (MASLD; formerly NAFLD), drug injury, autoimmune hepatitis, Wilson disease	High ALT and AST; fatigue; jaundice in more severe cases
Bile ducts (cholestasis)	Primary biliary cholangitis (small ducts), primary sclerosing cholangitis (large ducts), stones, tumors, biliary atresia	High ALP and GGT; itching; dark urine and pale stools; jaundice
Blood vessels (inflow)	Portal vein thrombosis, hepatic artery thrombosis (especially after transplant)	Varices, abdominal pain, ascites; sudden liver injury when artery clots
Blood vessels (outflow)	Budd-Chiari syndrome (hepatic vein block), sinusoidal obstruction syndrome, right heart failure	Enlarged tender liver, ascites, swelling of legs
Sinusoids and stroma	Fibrosis and cirrhosis from any long-term injury	Nodular liver, portal hypertension, low platelets
Tumors	Hepatocellular carcinoma (arises mainly in cirrhosis), cholangiocarcinoma (bile ducts), metastases (from the colon and elsewhere), benign hemangioma, adenoma, focal nodular hyperplasia	Often no symptoms early; found on surveillance ultrasound or imaging
Gallbladder and ducts	Gallstones, cholecystitis, choledocholithiasis, cholangitis	Right-upper pain after fatty meals, fever, jaundice

Jaundice: three anatomic places for the problem

Jaundice (yellow skin and eyes) appears when bilirubin builds up in the blood. Bilirubin follows a route: red cells > blood > liver uptake > conjugation > bile > gut. A problem at any step can cause jaundice:

Type	Where the problem is	What builds up	Examples
Prehepatic	Too much bilirubin is made before it reaches the liver	Unconjugated (indirect) bilirubin	Hemolysis (red cells destroyed quickly), large bruises

Type	Where the problem is	What builds up	Examples
Hepatic	The liver cells cannot take up, conjugate, or excrete bilirubin	Both types	Hepatitis, cirrhosis, Gilbert syndrome, newborn jaundice
Posthepatic (obstructive)	The bile duct is blocked	Conjugated (direct) bilirubin; dark urine and pale stools	Gallstone in the common bile duct, pancreatic head tumor, cholangiocarcinoma, strictures

Cirrhosis and portal hypertension: the anatomy of decompensation

In cirrhosis the scarred, nodular liver forces blood to travel through narrowed sinusoids and around nodules (see Figure 15). Pressure in the portal vein rises (Figure 11). This one change explains most complications:

Complication	Anatomical mechanism
Ascites	High sinusoidal pressure and low albumin push fluid into the abdomen; kidney retains sodium and water
Variceal bleeding	Collateral veins in the esophagus and stomach are thin-walled and swell under pressure
Hepatic encephalopathy	Ammonia-rich blood bypasses the liver through collaterals and reaches the brain
Splenomegaly and low platelets	Congested spleen traps blood cells
Hepatorenal syndrome	Circulation changes reduce blood flow to the kidneys even though they are structurally normal
Spontaneous bacterial peritonitis	Fluid in the abdomen can become infected; gut bacteria cross the wall of the intestine more easily
Liver cancer risk	Repeated injury and regeneration in cirrhosis increase the risk of cell errors; ultrasound surveillance is recommended for people at risk

Compensated vs decompensated

"Compensated" cirrhosis means the liver still copes and there are no major complications; many people live for years. "Decompensated" cirrhosis means complications such as ascites, variceal bleeding, jaundice, or encephalopathy have developed. Transplant evaluation is considered when a person becomes decompensated or develops certain liver tumors.

Biliary anatomy and disease

Condition	Anatomy involved	What happens
Gallstones	Gallbladder; Hartmann's pouch	Stones form from cholesterol or pigment; a stone in the neck causes colicky pain
Cholecystitis	Gallbladder wall; cystic duct	A stone blocks the cystic duct, leading to inflammation and infection
Choledocholithiasis	Common bile duct	A stone in the duct causes jaundice and can lead to cholangitis
Gallstone pancreatitis	Ampulla of Vater	A stone at the shared outlet blocks the pancreatic duct
Cholangitis	Bile ducts	Infection above a blockage; fever, jaundice, pain: an emergency
Primary sclerosing cholangitis	Large bile ducts inside and outside the liver	Scarring and narrowing of ducts gives a "beaded" look on MRCP
Primary biliary cholangitis	Small bile ducts in the portal tracts	Immune injury to small ducts; itching and fatigue

Matching tests to anatomy

Test	Part of the anatomy it reflects	What it tells you
ALT, AST	Hepatocyte membranes	Injury to liver cells
ALP, GGT	Bile-duct cells and canalicular membranes	Bile flow problems
Bilirubin	Uptake, conjugation, and excretion in bile	Bile flow and liver function
Albumin, INR	Protein synthesis in hepatocytes	Liver function reserve
Platelets, spleen size	Portal hypertension effect on the spleen	Clue to advanced fibrosis
Elastography, blood-based scores	Stiffness or markers of scarring	Estimate of fibrosis stage
Ultrasound, CT, MRI	Gross anatomy: size, shape, vessels, ducts, masses	Structural cause and complications
Biopsy	Microscopic architecture	Type and stage of disease

Key point

The liver is the "quiet workhorse" of the body. When you understand where each disease strikes, tests stop feeling like random numbers and start to feel like a map of a place you know.

CHAPTER 18

Surgery and Transplant Anatomy

Why the liver's structure makes these operations possible

Modern liver surgery is built on the segmental anatomy in Chapter 5. Because each segment has its own inflow, outflow, and bile drainage, surgeons can remove or transplant precisely defined parts. This chapter is an overview of the anatomy behind these operations, not medical advice.

Common liver operations and the anatomy they use

Operation	Segments or structures involved	Notes
Right hepatectomy	Segments 5 to 8 (with the right hepatic vein, right portal branch, and right hepatic artery)	Leaves segments 1 to 4; remnant must be large enough
Left hepatectomy	Segments 2 to 4 (sometimes with 1)	Requires care of the middle hepatic vein
Left lateral sectionectomy	Segments 2 and 3	Often used for a pediatric graft
Segmentectomy	One segment	Preserves liver tissue; needs a segment-specific approach
Cholecystectomy	Gallbladder; cystic duct and artery in Calot's triangle	The "critical view of safety" protects the common bile duct
Kasai portoenterostomy	Bile ducts at the porta hepatis connected to a loop of intestine	For biliary atresia
TIPS	Hepatic vein to portal vein branch shunt inside the liver	Lowers portal pressure

Liver transplant: what is connected to what

In a standard (deceased-donor) whole-liver transplant, the diseased liver is removed and the donor liver is sewn into the same place. Four sets of connections must be made, and each depends on an anatomical feature you have already learned:

Connection	What is joined	Anatomical notes
Vena cava (outflow)	Donor IVC or hepatic vein to the recipient IVC	The "piggyback" technique keeps the recipient's IVC in place and joins the donor's hepatic veins to it
Portal vein	Donor portal vein to recipient portal vein	Requires a portal vein with good flow; a clot may need a graft or different route
Hepatic artery	Donor artery to the recipient hepatic artery (or an alternative)	Small vessel; clotting (thrombosis) is a serious early risk; arterial variations (Chapter 6) are checked before surgery

Connection	What is joined	Anatomical notes
Bile duct	Duct-to-duct (donor to recipient common bile duct) or to a loop of intestine (Roux-en-Y hepaticojejunostomy)	Bile-duct blood supply comes from the hepatic artery, so arterial problems can cause duct strictures

Living-donor liver transplant

Because the liver can regrow, part of a healthy donor's liver can be given to a recipient. Both the donor's remaining liver and the transplanted part grow toward full size in the following weeks to months.

Graft type	Segments	Who it is used for	Key anatomical consideration
Right lobe graft	Segments 5 to 8 (with or without the middle hepatic vein)	Most adult recipients	The donor keeps segments 1 to 4; portal and hepatic vein branches and the right hepatic duct are carefully mapped
Left lobe graft	Segments 2 to 4	Smaller adults and larger children	Smaller graft size; may not be enough for a large recipient
Left lateral segment graft	Segments 2 and 3	Infants and small children	Very good match in size; safest for the donor
Split liver (from a deceased donor)	Left lateral segments to a child; right trisegment to an adult	Two recipients from one liver	Requires a favorable anatomy, including arteries and bile ducts

Size matters

Surgeons and transplant teams commonly use **graft-to-recipient weight ratio** (often a target of about 0.8% or more) and the **remaining liver volume in the donor** (often at least about 30 to 35% of the original liver) as guides. Exact standards vary between centers and change over time. All of this is planned with CT or MRI scans that map every artery, vein, and duct. Anyone considering living donation should hear the specifics directly from a transplant center.

Key point

Understanding the map (the segments, the porta hepatis, and the double blood supply) helps patients and families make sense of transplant evaluation and surgery. For more about the transplant journey, see TLHF's companion education guides.

CHAPTER 19

Protecting Your Liver

What the anatomy tells us about staying healthy

The liver forgives a great deal and regrows, but it is not invincible. Damage is often **silent** until late. The best defense is prevention and early detection. The table links each habit to the anatomy behind it.

Habit	Anatomy behind it	What it does
Limit or avoid alcohol	Alcohol is processed in zone 3 hepatocytes, producing toxic by-products	Prevents fat buildup, inflammation, and scarring; ask your team what is safe for you
Keep a healthy weight and stay active	Fat accumulates inside hepatocytes and around sinusoids	Lowers risk of fatty liver disease (MASLD) and its progression
Control blood sugar, blood pressure, and cholesterol	The liver is a central organ of metabolism	Reduces fat and scarring; supports the heart too
Get vaccinated (hepatitis A and B)	Viruses enter hepatocytes through blood or the gut	Prevents infection; ask your clinician if you are up to date
Get tested for hepatitis B and C	Chronic infection can be silent while it scars the liver	Health authorities recommend one-time hepatitis C testing for all adults and hepatitis B testing at least once; treatment is highly effective
Use medicines and supplements wisely	Drugs are broken down in hepatocytes; acetaminophen overdose injures zone 3	Follow label limits; tell your team about all herbs and supplements; avoid combining products that contain acetaminophen
Practice safe sex and never share needles or personal items	Hepatitis B and C spread through blood and body fluids	Prevents infection
Handle food and water safely; wash hands	Hepatitis A and E spread through the gut	Prevents infection, especially when traveling
Avoid toxic mushrooms and chemical exposures	Some toxins are concentrated by the liver	Prevents acute injury; use protective equipment with solvents
Do not smoke	Smoking raises the risk of liver cancer and worsens fibrosis	Protects the liver and blood vessels
Get screened if at risk	Damage is silent until late	People with diabetes, obesity, heavy alcohol use, viral hepatitis, or a family history may need liver tests and elastography or ultrasound; those with cirrhosis need surveillance for liver tumors

Natural does not mean safe

Herbal remedies, "detox" products, and high-dose vitamin A or other supplements can injure the liver even though they are sold as natural. Ask your pharmacist or healthcare team before starting one, especially if you already have liver disease.

Six questions for your next visit

Ask your healthcare team: What are my liver tests and what do they mean? Do I have fatty liver or scarring? Am I protected against hepatitis A and B? Have I been tested for hepatitis C? Are any of my medicines a concern for my liver? How often should I be checked?

From TLHF

Liver health is a team effort, and every step helps. Even small changes matter.

Health. Awareness. Hope.

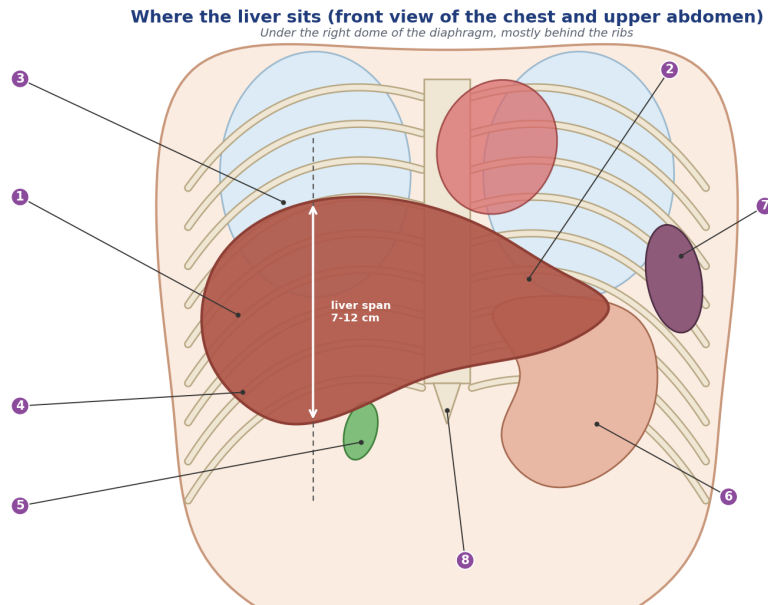
PART 6

Study Tools

LABELING EXERCISE L1

Label the diagram: where the liver sits

Write the name of each numbered structure. Check your work with the answer key in the next section.

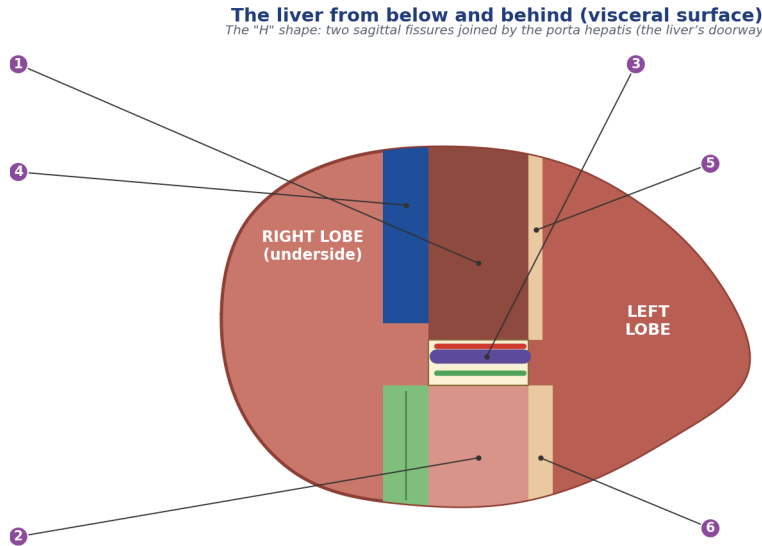


#	Your answer	#	Your answer
1		5	
2		6	
3		7	
4		8	

LABELING EXERCISE L2

Label the diagram: the underside of the liver

Name each numbered part of the visceral (under) surface of the liver.

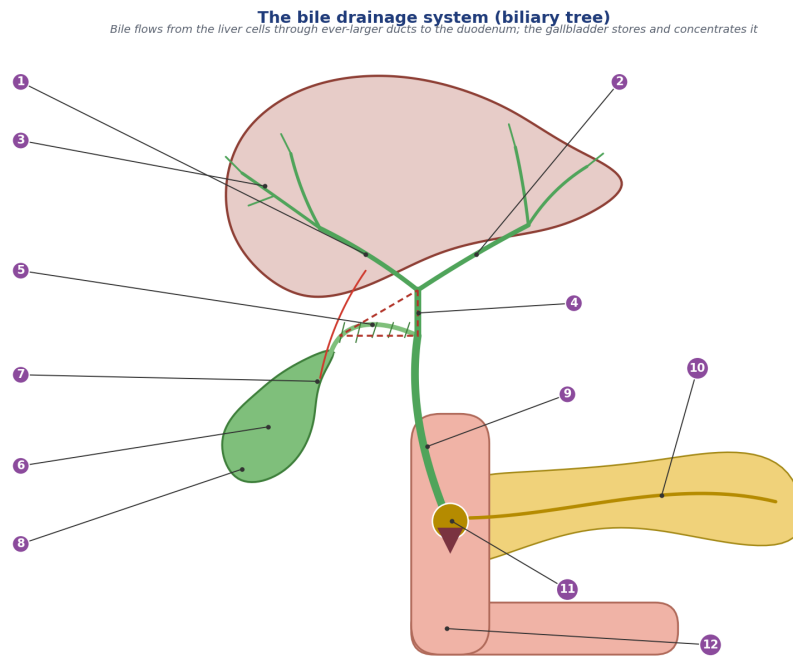


#	Your answer	#	Your answer
1		4	
2		5	
3		6	

LABELING EXERCISE L3

Label the diagram: the bile ducts and gallbladder

Name each numbered part of the biliary tree.



#	Your answer	#	Your answer
1		7	
2		8	
3		9	
4		10	
5		11	
6		12	

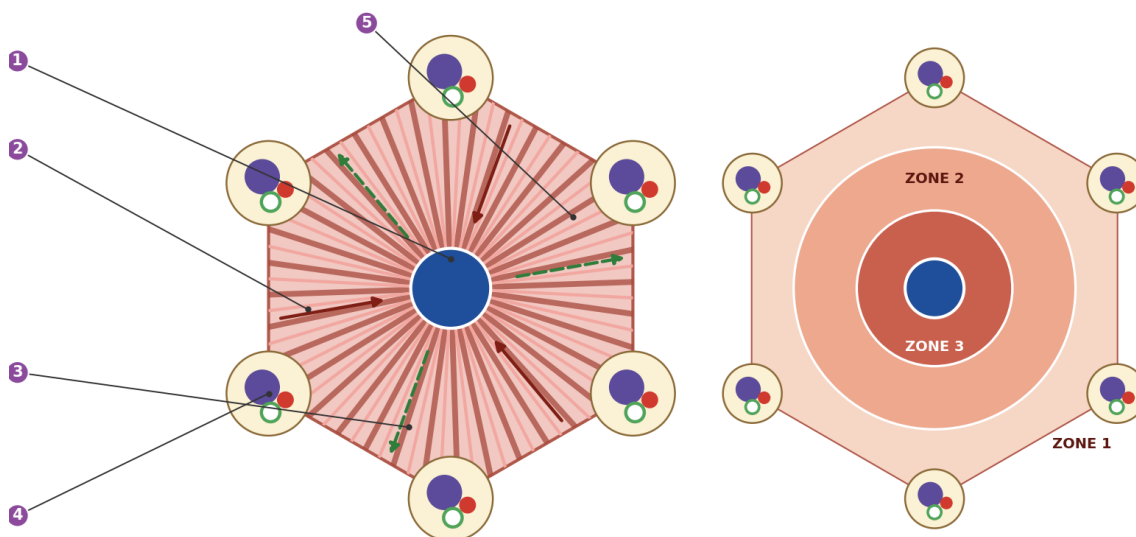
LABELING EXERCISE L4

Label the diagram: the liver lobule and its zones

Name each numbered structure of the liver lobule.

The liver lobule and its zones

Left: the classic hexagonal lobule seen end-on. Right: the three metabolic zones (zone 1 near the portal tract, zone 3 near the central vein)



#	Your answer	#	Your answer
1		4	
2		5	
3			

Answer keys: labeling exercises

Compare with the labeled diagrams earlier in the guide (Figure 2, Figure 4, Figure 12, and Figure 13).

L1: Where the liver sits

1	Right lobe of the liver	5	Gallbladder (at the lower border)
2	Left lobe (crosses the midline)	6	Stomach
3	Upper border: about the 5th rib space	7	Spleen
4	Lower border follows the right costal margin (rib edge)	8	Xiphoid process

L2: The underside of the liver

1	Caudate lobe (behind the porta)	4	Inferior vena cava (groove)
2	Quadrante lobe (in front of the porta)	5	Ligamentum venosum fissure
3	Porta hepatis (portal vein, hepatic artery, bile ducts enter and leave)	6	Ligamentum teres fissure

L3: Bile ducts and gallbladder

1	Right hepatic duct	7	Gallbladder neck / Hartmann's pouch
2	Left hepatic duct	8	Gallbladder fundus
3	Intrahepatic bile ducts	9	Common bile duct
4	Common hepatic duct	10	Main pancreatic duct
5	Cystic duct (spiral valve inside)	11	Ampulla of Vater with the sphincter of Oddi
6	Gallbladder body	12	Duodenum

L4: Liver lobule and zones

1	Central vein (collects blood, joins hepatic vein)	4	Portal triad
2	Hepatocyte plates (one cell thick)	5	Bile canaliculi: bile flows outward (green dashes)
3	Sinusoids: blood flows inward (red arrows)		

Review quiz: 25 questions

Circle the best answer for each question. The answer key follows the quiz. Score yourself: 22 to 25 = excellent; 17 to 21 = good; below 17 = review the chapters and try again.

1. The liver is described as "intraperitoneal" for most of its surface, except for the bare area, which touches the:
A. Stomach B. Diaphragm C. Right kidney D. Spleen
2. About what share of the heart's output flows through the liver each minute?
A. About 5% B. About 10% C. About 25% D. About 50%
3. Which ligament is the remnant of the fetal umbilical vein?
A. Ligamentum venosum B. Ligamentum teres C. Coronary ligament D. Falciform ligament
4. Which lobe lies between the inferior vena cava and the ligamentum venosum?
A. Quadrate lobe B. Right lobe C. Caudate lobe D. Left lateral lobe
5. The functional right and left halves of the liver are divided by a line running from the gallbladder fossa to the:
A. Falciform ligament B. Inferior vena cava C. Ligamentum venosum D. Right triangular ligament
6. The Couinaud classification divides the liver into how many segments?
A. Four B. Six C. Eight D. Twelve
7. Which hepatic vein runs in Cantlie's line?
A. Right B. Middle C. Left D. Caudate
8. Segment 1 is the:
A. Caudate lobe B. Quadrate lobe C. Left lateral segment D. Right posterior segment
9. About what share of the liver's blood flow comes from the portal vein?
A. 25% B. 50% C. 75% D. 100%
10. The hepatic artery usually arises from the:
A. Superior mesenteric artery B. Celiac trunk C. Renal artery D. Aorta directly at L4
11. The portal vein is formed by the union of the superior mesenteric vein and the:
A. Inferior vena cava B. Splenic vein C. Left renal vein D. Hepatic vein
12. Which structure is NOT part of the portal triad?
A. Hepatic artery branch B. Portal vein branch C. Bile duct D. Central vein
13. Which of these is a portosystemic collateral site?
A. Lower esophagus B. Hilum of the kidney C. Ureter D. Thyroid
14. Caput medusae results from enlargement of veins around the:
A. Elbow B. Navel C. Neck D. Knee
15. The hepatic veins empty into the:
A. Portal vein B. Inferior vena cava C. Right atrium directly D. Splenic vein
16. The common bile duct is formed by the union of the common hepatic duct and the:
A. Pancreatic duct B. Cystic duct C. Right hepatic duct D. Left hepatic duct
17. Which hormone makes the gallbladder contract after a fatty meal?
A. Insulin B. Cholecystikinin (CCK) C. Aldosterone D. Gastrin

-
- 18.** Calot's triangle is bounded by the cystic duct, the common hepatic duct, and the:
A. Portal vein **B.** Lower edge of the liver **C.** Spleen **D.** Pancreatic duct
- 19.** In a lobule, blood flows:
A. From the central vein to the portal tracts **B.** From the portal tracts to the central vein **C.** Only in the bile ducts **D.** Out of the liver in the sinusoids only
- 20.** The space of Disse lies between:
A. Two hepatocytes **B.** The sinusoid wall and the hepatocytes **C.** The bile duct and artery **D.** The liver and diaphragm
- 21.** Which cell stores vitamin A and lays down scar tissue when activated?
A. Kupffer cell **B.** Hepatic stellate cell **C.** Cholangiocyte **D.** Pit cell
- 22.** Which cells are the liver's resident macrophages?
A. Hepatocytes **B.** Kupffer cells **C.** Stellate cells **D.** Cholangiocytes
- 23.** Zone 3 of the liver acinus is closest to the:
A. Portal tract **B.** Central vein **C.** Bile duct **D.** Gallbladder
- 24.** The fetal ductus venosus becomes the:
A. Ligamentum teres **B.** Ligamentum venosum **C.** Falciform ligament **D.** Coronary ligament
- 25.** Which test mainly reflects the liver's synthetic (production) function?
A. ALT **B.** INR (or albumin) **C.** ALP **D.** GGT

Quiz answer key with short explanations

1	B	The bare area lies directly against the diaphragm with no peritoneal cover.
2	C	About 25% of cardiac output, roughly 1.5 L/min.
3	B	The umbilical vein becomes the ligamentum teres.
4	C	The caudate lobe (segment 1) lies between the IVC and the ligamentum venosum.
5	B	Cantlie's line runs from the gallbladder fossa to the IVC.
6	C	Couinaud described eight segments.
7	B	The middle hepatic vein runs in Cantlie's line.
8	A	Segment 1 is the caudate lobe.
9	C	The portal vein supplies about 75% of blood flow, the hepatic artery about 25%.
10	B	The celiac trunk gives the common hepatic artery.
11	B	The SMV and splenic vein unite behind the pancreatic neck.
12	D	The central vein is part of the lobule, not the portal triad.
13	A	The lower esophagus links the left gastric (portal) and esophageal (systemic) veins.
14	B	Paraumbilical veins can reopen and swell around the navel.
15	B	Hepatic veins empty into the IVC just below the diaphragm.
16	B	The cystic duct joins the common hepatic duct to make the common bile duct.
17	B	CCK from the duodenum contracts the gallbladder and relaxes the sphincter of Oddi.
18	B	The third border of Calot's triangle is the lower edge of the liver.
19	B	Blood flows inward from portal tracts to the central vein.
20	B	The space of Disse separates the sinusoid wall from hepatocytes.
21	B	Stellate cells store vitamin A and become scar-forming cells.
22	B	Kupffer cells are the liver macrophages.
23	B	Zone 3 is pericentral, closest to the central vein.
24	B	The ductus venosus becomes the ligamentum venosum.
25	B	INR and albumin reflect synthesis; ALT, ALP, and GGT mostly reflect injury.

Anatomy by the numbers: quick reference

Item	Typical adult value
Weight	About 1.2 to 1.6 kg (about 2 to 2.5% of body weight)
Dimensions	About 20 to 22 cm wide, 15 cm high on the right, 10 to 13 cm thick
Volume	About 1,200 to 1,500 mL
Vertebral levels	About T8 to T9 (top) to L2 to L3 (right lobe lower border)
Upper border	About the 5th rib space at the right midclavicular line
Liver span (midclavicular line)	About 7 to 12 cm on percussion or ultrasound; varies by method and body size
Total blood flow	About 1.5 L/min (about 25% of cardiac output)
Portal vein share of flow / hepatic artery share	About 75% / about 25%
Portal vein length / width	About 8 cm / up to about 13 mm
Normal portal pressure; HVPG	About 5 to 10 mmHg; HVPG normal 1 to 5 mmHg, 10 mmHg or more clinically significant
Couinaud segments	8 (numbered 1 to 8; segment 4 splits into 4a and 4b)
Hepatic veins	3 main (right, middle, left) plus small caudate and inferior right veins
Number of lobules / lobule size	About 50,000 to 100,000 / about 1 to 2 mm
Hepatocytes	About 80% of liver volume; 60 to 70% of cells; life span about 200 to 300 days
Space of Disse width	About 0.2 to 0.5 micrometers
LSEC pore (fenestra) size	About 100 to 150 nm
Bile production	About 500 to 1,000 mL/day
Gallbladder	7 to 10 cm long; holds about 30 to 50 mL; concentrates bile 5 to 10 times
Common hepatic duct / common bile duct	About 4 to 6 cm / about 7 to 11 cm; CBD normally up to about 6 mm wide
Regeneration	Volume mostly restored within weeks to a few months after resection
Arterial variations	Some variation in about 40 to 45% of people
Fetal liver	Bile production about week 12; blood formation shifts to marrow late in pregnancy

Values are typical ranges from standard anatomy and physiology references and vary between individuals and studies. A medical reviewer should verify all figures before wide distribution.

Glossary

Acinus (liver)	A microscopic unit centered on a portal tract and its blood supply, divided into zones 1, 2, and 3.
Albumin	Main blood protein made by the liver; keeps fluid in blood vessels.
ALT / AST	Enzymes released when liver cells are injured.
Ampulla of Vater	Where the common bile duct and main pancreatic duct usually join and open into the duodenum.
Ascites	Buildup of fluid in the abdomen.
Bare area	Part of the liver surface attached directly to the diaphragm without peritoneal cover.
Bile	Fluid made by the liver that aids fat digestion and carries waste.
Bile canaliculus	Microscopic channel between adjacent hepatocytes where bile is first secreted.
Biliary tree	The system of ducts that carries bile from the liver to the intestine.
Bilirubin	Yellow pigment from the breakdown of red blood cells; excreted in bile.
Calot's triangle	Region bounded by the cystic duct, common hepatic duct, and liver edge; surgical landmark.
Cantlie's line	Plane from the gallbladder fossa to the IVC that separates the functional right and left livers.
Caudate lobe	Segment 1; lies between the IVC and the ligamentum venosum.
Central vein	Small hepatic vein at the center of a lobule.
Cholangiocyte	Bile-duct lining cell.
Cirrhosis	Advanced scarring of the liver with nodules and distorted blood flow.
Collateral	A side-route vein that opens when the main route is blocked.
Common bile duct	Duct that carries bile from the liver and gallbladder to the duodenum.
Couinaud segments	Eight functional segments of the liver, each with its own blood supply and drainage.
Cystic duct	Duct connecting the gallbladder to the common hepatic duct.
Ductus venosus	Fetal channel that lets blood bypass the liver; becomes the ligamentum venosum.
Enterohepatic circulation	Recycling of bile acids between liver and intestine.
Falciform ligament	Peritoneal fold attaching the liver to the front abdominal wall.
Fibrosis	Scar tissue formation.
Gallbladder	Sac under the liver that stores and concentrates bile.
Glisson's capsule	Thin connective tissue coat surrounding the liver and extending into it with vessels.
Hepatic artery	Artery that supplies the liver with oxygen-rich blood.
Hepatic stellate cell	Cell in the space of Disse that stores vitamin A and makes scar tissue when activated.
Hepatic vein	Vein that carries blood from the liver to the IVC.
Hepatocyte	The main liver cell.

HVPG	Hepatic venous pressure gradient; a measure of portal pressure.
Jaundice	Yellowing of skin and eyes from excess bilirubin.
Kupffer cell	Liver macrophage in the sinusoids.
Ligamentum teres	Round ligament: remnant of the fetal umbilical vein.
Ligamentum venosum	Remnant of the fetal ductus venosus.
Lobule	Hexagonal microscopic unit centered on a central vein.
LSEC	Liver sinusoidal endothelial cell; lines sinusoids and has pores.
MASLD	Metabolic dysfunction-associated steatotic liver disease (fatty liver linked to metabolic risk factors).
Parenchyma	Working tissue of an organ.
Peritoneum	Thin membrane lining the abdomen and covering its organs.
Porta hepatis	Transverse groove on the underside of the liver where vessels and ducts enter and leave.
Portal hypertension	Raised pressure in the portal venous system.
Portal triad	Portal vein branch, hepatic artery branch, and bile duct traveling together.
Portal vein	Vein carrying blood from the gut, spleen, and pancreas to the liver.
Pringle maneuver	Temporary compression of the portal triad to control liver bleeding.
Quadrant lobe	Underside lobe between the gallbladder and the ligamentum teres (segment 4b).
Sinusoid	Wide, leaky capillary between hepatocyte plates.
Space of Disse	Narrow gap between sinusoid wall and hepatocytes.
Sphincter of Oddi	Muscle around the ampulla that controls flow of bile and pancreatic juice.
Steatosis	Fat accumulation in liver cells.
TIPS	Transjugular intrahepatic portosystemic shunt; a stent linking a hepatic vein to a portal vein branch.
Varices	Swollen veins, often in the esophagus or stomach.
Zone 3	Region of a liver acinus nearest the central vein; lowest oxygen, most drug metabolism.

Resources and next steps

These organizations offer reliable, patient-friendly information about liver anatomy and liver health. Please confirm website addresses and phone numbers before sharing this guide, as they can change.

Organization	What it offers	Website
National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)	Liver disease basics, tests, treatments	niddk.nih.gov
American Liver Foundation	Patient education and support for liver disease	liverfoundation.org
Hepatitis B Foundation	Education and support for hepatitis B	hepb.org
Centers for Disease Control and Prevention (CDC): viral hepatitis	Hepatitis A, B, and C information, testing, vaccines	cdc.gov/hepatitis
Organ Procurement and Transplantation Network (OPTN) / UNOS	Transplant allocation and patient information	optn.transplant.hrsa.gov; unos.org
MedlinePlus (U.S. National Library of Medicine)	Plain-language health topics and medical tests	medlineplus.gov

Where to go from here

- Bring this guide, your lab results, and your imaging reports to your next appointment and ask your care team to point out the structures on your own images.
- Use the labeling exercises to teach a family member; teaching is the best way to learn.
- Ask TLHF about companion education guides on liver disease, transplant, and healthy living.

Thank you for learning with TLHF

You now know more about how the liver is built than most people ever learn. Knowledge is the beginning of good questions, and good questions are the beginning of good care. **Health. Awareness. Hope.**

Write anything you want to remember or ask your healthcare team: