Unit 3: Anatomy of the Digestive and Excretory Systems

Subject: Human Anatomy

Unit 3: Anatomy of the Digestive and Excretory Systems

(Digestive Tract & Accessory Organs • Abdominal Cavity & Divisions • Liver, Pancreas, Gallbladder • Excretory/Urinary System • Applied Anatomy)

Video Lectures (YouTube):

3.1 Digestive System – Overview

The **digestive system** converts food into absorbable molecules and eliminates waste. It comprises:

- **Alimentary canal (GI tract):** mouth → pharynx → esophagus → stomach → small intestine (duodenum, jejunum, ileum) → large intestine (cecum, colon, rectum) → anal canal.
- **Accessory organs: salivary glands**, **liver**, **gallbladder**, **pancreas**.

3.1.1 Wall of the GI tract (esophagus to anal canal)

Layer (inner → outer)	Key components	Function
Mucosa	epithelium (type varies), lamina propria, muscularis mucosae	secretion, absorption, protection
Submucosa	vessels, glands, **Meissner (submucosal) plexus**	supports mucosa; controls secretions
Muscularis externa	inner circular + outer longitudinal; **Auerbach (myenteric) plexus**	peristalsis/segmentation
Serosa/Adventitia	visceral peritoneum or fibrous CT	reduces friction or anchors

Epithelial changes: stratified squamous (esophagus) → simple columnar (stomach, intestines) → stratified squamous (anal canal).

3.2 Structure of Organs of the Digestive System

3.2.1 Mouth & Salivary Glands

- **Teeth & tongue** (mastication, bolus formation; taste).
- **Major salivary glands: parotid** (serous; Stensen duct), **submandibular** (mixed; Wharton duct), **sublingual** (mucous).
- **Saliva:** amylase, lipase (minor), mucus, IgA → lubrication, starch start.

3.2.2 Pharynx & Esophagus

- Muscular tube; upper & lower **esophageal sphincters**.
- **Esophagus**: stratified squamous epithelium; transitions to gastric mucosa at Z-line.
- **Applied:** GERD, hiatal hernia; aspiration risk if coordination is poor.

3.2.3 Stomach

- Regions: **cardia, fundus, body, pylorus**.

- **Rugae** (folds), **gastric pits** with **parietal cells** (HCl, intrinsic factor), **chief cells** (pepsinogen), **mucous neck cells**, **G cells** (gastrin).
- **Function:** mixing → **chyme**; protein digestion begins.

3.2.4 Small Intestine

- **Duodenum (C-shaped, retroperitoneal):** receives bile & pancreatic juice via **major duodenal papilla**; **Brunner glands** (alkaline mucus).
- **Jejunum:** tall **plicae circulares**, many villi → absorption.
- **Ileum: Peyer patches** (lymphoid).
- **Enterocytes** with **microvilli (brush border)** host enzymes; **goblet cells** add mucus.

3.2.5 Large Intestine

- **Cecum** with **appendix** (lymphoid), **colon** (ascending, transverse, descending, sigmoid), **rectum**.
- Features: **teniae coli, haustra, omental appendices**; absorbs water/electrolytes; houses microbiota.

3.2.6 Anal Canal

- Upper part: visceral innervation; internal sphincter (smooth).
- Lower part: somatic innervation (inferior rectal nerve); **external sphincter (skeletal)**.
- **Pectinate line** divides vascular/nerve supply & hemorrhoid types (internal vs external).

3.3 Abdominal Cavity – Peritoneum & Divisions

3.3.1 Peritoneum & Mesenteries

- **Parietal** vs **visceral peritoneum**; **peritoneal cavity** contains a thin film (potential space).
- **Mesenteries** (e.g., **mesentery proper**, **transverse mesocolon**) suspend viscera; pathways for vessels/nerves.
- **Omenta: greater** (fat-laden apron; immune role) & **lesser** (stomach ↔ liver).

3.3.2 Abdominal Regions (for localization)

- **Four quadrants:** RUQ, LUQ, RLQ, LLQ.
- **Nine regions:** right/left **hypochondriac**, **epigastric**; right/left **lumbar**, **umbilical**; right/left **iliac (inguinal)**, **hypogastric (pubic)**.

Organ highlights (typical)
RUQ: liver (right lobe), gallbladder, duodenum, head of pancreas
LUQ: stomach, spleen, left lobe liver, body/tail pancreas
RLQ: cecum, **appendix**, right ovary/ureter
LLQ: sigmoid colon, left ovary/ureter

3.3.3 Foregut–Midgut–Hindgut (arterial supply)

- **Foregut:** esophagus (abdominal), stomach, proximal duodenum, liver, GB, pancreas, spleen (embryologically) → **Celiac trunk**.
- **Midgut:** distal duodenum → 2/3 transverse colon → **SMA**.
- **Hindgut:** distal 1/3 transverse colon → rectum (above pectinate) → **IMA**.

3.4 Liver – Structure & Functions

3.4.1 Gross anatomy

- **Largest gland**; right & left lobes (plus quadrate, caudate).
- **Porta hepatis:** entry of **portal vein** (nutrient-rich), **hepatic artery proper** (oxygenated), exit of **hepatic ducts**.
- **Peritoneal reflections:** falciform ligament; lesser omentum (hepatoduodenal ligament contains **portal triad**).

3.4.2 Microanatomy (lobule concept)

- **Hepatocytes** in plates → **sinusoids** (fenestrated) with **Kupffer cells** (macrophages) → **central vein**.
- **Bile canaliculi** → bile ducts (in **portal triads** with hepatic artery & portal venule).

3.4.3 Functions (exam list)

- **Bile** production; **carb/lipid/protein** metabolism; **detox** (cytochrome P450); **storage** (glycogen, vitamins A/D/B12, iron); **plasma proteins** (albumin, clotting factors); **immune** filtering.

Applied: jaundice (pre-/intra-/post-hepatic causes), portal hypertension (ascites, varices), fatty liver.

3.5 Gallbladder – Storage & Concentration of Bile

- Parts: **fundus, body, neck** (with **Hartmann pouch**); **cystic duct** (spiral fold) joins **common hepatic duct** → **common bile duct (CBD)**.
- **CCK** triggers contraction when fat enters duodenum.
- **Calot's triangle** (cystic duct, common hepatic duct, cystic artery) is key in cholecystectomy.

Applied: cholelithiasis (stones) → biliary colic; referred pain to right shoulder (phrenic irritation via diaphragm).

3.6 Pancreas – Dual Gland

- **Retroperitoneal**; **head (with uncinate), neck, body, tail** (tail to splenic hilum).
- **Exocrine acini:** digestive enzymes (trypsinogen, lipase, amylase) into **main pancreatic duct (Wirsung)** ± **accessory (Santorini)**; often unite with CBD at **hepatopancreatic ampulla (of Vater)** guarded by **sphincter of Oddi**.
- **Endocrine islets: β-cells (insulin)**, **α (glucagon)**, **δ (somatostatin)**, **PP cells**.

Applied: pancreatitis (epigastric pain radiating to back), malabsorption if duct blocked.

3.7 Excretory System – Overview

The excretory/urinary system maintains **fluid–electrolyte balance**, removes **nitrogenous wastes**, and supports **blood pressure & RBC production**.

Organs: kidneys, **ureters**, **urinary bladder**, **urethra**.

3.7.1 Kidneys – Gross & Micro

- **Retroperitoneal**; right kidney slightly lower.
- **Hilum → sinus**: **renal artery**, **vein**, **pelvis** (anterior→posterior usually: vein, artery, pelvis).
- **Cortex**; **medulla** with **pyramids → papillae → minor calyces → major calyces → renal pelvis**.

Nephron

Segment	Key features	Main functions
Renal corpuscle (glomerulus + Bowman capsule)	Fenestrated capillaries + filtration membrane	**Filtration** of plasma → filtrate
PCT	Brush border	Reabsorbs ~65% water/Na^+; glucose/AA nearly all
Loop of Henle	Descending thin; ascending thick	Counter-current system; concentrates/dilutes
DCT	Macula densa near afferent arteriole	Na^+ fine-tuning (aldosterone)
Collecting duct	Principal/intercalated cells	Water reabsorption (ADH); acid–base balance

Juxtaglomerular apparatus (JGA): macula densa + **JG cells** → **renin** (RAAS) for BP control.
Endocrine roles: EPO (RBCs), **renin**, activation of **vitamin D (calcitriol)**.

3.7.2 Ureters

- Muscular tubes (peristalsis) from renal pelvis to bladder.
- **Three natural narrowings** (stone sites): **pelvi-ureteric junction (PUJ)**, **crossing pelvic brim**, **uretero-vesical junction (UVJ)**.

3.7.3 Urinary Bladder

- **Detrusor** (smooth muscle) with **rugae**; **trigone** smooth (ureteric orifices & internal urethral orifice).
- **Innervation:** parasympathetic (pelvic splanchnic) contracts detrusor/relaxes internal sphincter; sympathetic does the opposite; somatic **pudendal** controls external sphincter.
- **Micturition reflex**: stretch → parasympathetic activation.

3.7.4 Urethra

- **Male: prostatic → membranous → spongy**; longer; dual urinary/ reproductive roles.
- **Female:** short; higher UTI risk; separate from reproductive tract.

3.8 Applied Anatomy (Digestive & Urinary)

3.8.1 Digestive highlights

- **Referred pain maps:**
  - **Gallbladder** → right shoulder/scapula (diaphragmatic irritation).
  - **Pancreas** → mid-back.
  - **Appendix** → periumbilical → RLQ (**McBurney point**).
- **Portal hypertension:** porto-systemic anastomoses (esophageal varices, caput medusae, hemorrhoids).
- **Fiber & hydration** support colonic motility; straining risks hemorrhoids/hernia.

3.8.2 Urinary highlights

- **Renal colic:** pain along ureteral path at three constrictions; encourage **hydration & gentle mobility** (medical evaluation first).
- **UTI education:** void regularly, front-to-back hygiene, adequate fluids; avoid unnecessary retention.
- **Pelvic floor**: training improves continence; excessive straining can weaken support.
- **Practice safety:** avoid strong **kumbhaka/bandha** in uncontrolled **HTN, renal/cardiac disease**; favor **gentle diaphragmatic breathing** and **restorative postures**.

3.9 Quick Integration Charts

3.9.1 Digestive enzymes (where they act)

Site	Key secretions	Target
Mouth	**Amylase**	Starch → maltose
Stomach	**Pepsin**, HCl	Proteins (initial)
Pancreas (into duodenum)	**Trypsin/Chymotrypsin**, **Lipase**, **Amylase**	Proteins, fats, carbs
Small intestine (brush border)	**Disaccharidases**, **Peptidases**	Final breakdown → absorption

3.9.2 Fluid handling (24h, approximate)

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Ingested + secreted ~ 8–9 L → Small intestine absorbs most → Colon reclaims ~1–2 L → Stool ~100–200 mL
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Unit Summary

Food travels through a specialized tube whose wall (mucosa → serosa) is optimized for **secretion, absorption, and propulsion**. The **liver** (dual blood supply) produces bile and governs metabolism; the **gallbladder** stores/concentrates bile; the **pancreas** supplies enzymes and hormones. The **peritoneum, mesenteries, and abdominal regions** organize viscera and guide clinical localization. The **kidneys** filter blood via millions of nephrons, regulate volume/electrolytes, and secrete renin/EPO; **ureters** conduct urine by peristalsis; the **bladder and urethra** coordinate storage and voiding. Applied anatomy connects these structures to symptoms (referred pain, colic), procedures (pulses, quadrants), and safe practice choices in Yoga & Naturopathy.

Key Terms

- **Mucosa/Submucosa/Auerbach–Meissner plexuses • Peyer patches • Plicae circulares**
- **Celiac/SMA/IMA • Portal triad (hepatic artery, portal vein, bile duct) • Kupffer cell**
- **Calot’s triangle • Ampulla of Vater, Sphincter of Oddi**
- **Nephron (PCT, Loop, DCT, Collecting duct) • JGA (macula densa, renin)**
- **PUJ/UVJ • Detrusor, Trigone • RAAS, EPO, Calcitriol**

Self-Assessment

MCQs

1. **Type II pneumocytes** in the alveoli secrete:
   a) Pepsin b) Surfactant c) Bile d) Renin
2. The **portal triad** contains all **except**:
   a) Hepatic artery b) Portal vein c) Common hepatic duct d) Hepatic vein
3. The **main pancreatic duct** usually joins the **common bile duct** to open into the:
   a) Minor duodenal papilla b) Major duodenal papilla c) Pyloric canal d) Jejunal fold
4. Natural **ureteric constrictions** include all **except**:
   a) Pelvi-ureteric junction b) Crossing pelvic brim c) Uretero-vesical junction d) Mid-ureteral valve
5. **Peyer patches** are prominent in the:
   a) Duodenum b) Jejunum c) Ileum d) Sigmoid colon

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Answer key: 1-b, 2-d, 3-b, 4-d, 5-c

Short Answer

1. List the **four layers** of the GI tract and one function of each.
2. Outline the **dual blood supply** of the liver and two key functions of hepatocytes.
3. Name the **parts of the pancreas** and the ducts; state where they open.
4. Trace **urine flow** from collecting duct to urethra, naming all chambers.
5. State the **three ureteric constrictions** and their clinical importance.

Reflective/Application

1. A participant has **right upper quadrant pain** after a fatty meal and shoulder-tip discomfort. Which organ is likely involved? Explain the **referred pain pathway**.
2. During a relaxation class, someone reports **flank-to-groin colicky pain** and restlessness. What **anatomical pathway** and **structures** are implicated? What immediate non-pharmacological supports are reasonable while arranging medical care?

End of Unit 3: Anatomy of the Digestive and Excretory Systems