

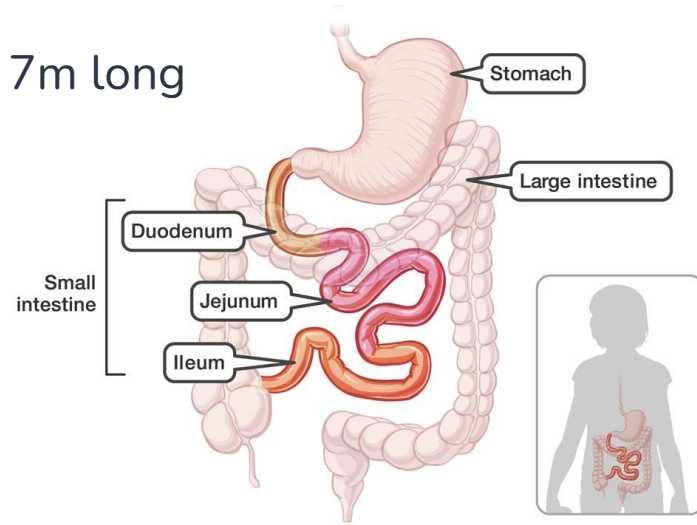


9.5 DIGESTION IN THE SMALL & LARGE INTESTINES

P. 412 - 420

STRUCTURE OF THE SMALL INTESTINE

- X Most **digestion** and **absorption** of nutrients occurs here
- X 2.5 cm in diameter and up to 7m long
- X Made up of three sections:
 - X duodenum
 - X jejunum
 - X ileum



SECTIONS OF THE SMALL INTESTINE

Duodenum

The duodenum is the **first 25-30 cm** and is where most **enzymes** are added and where **digestion** in the small intestine begins

Jejunum

In the jejunum, digestion continues and **some** nutrients are **absorbed**

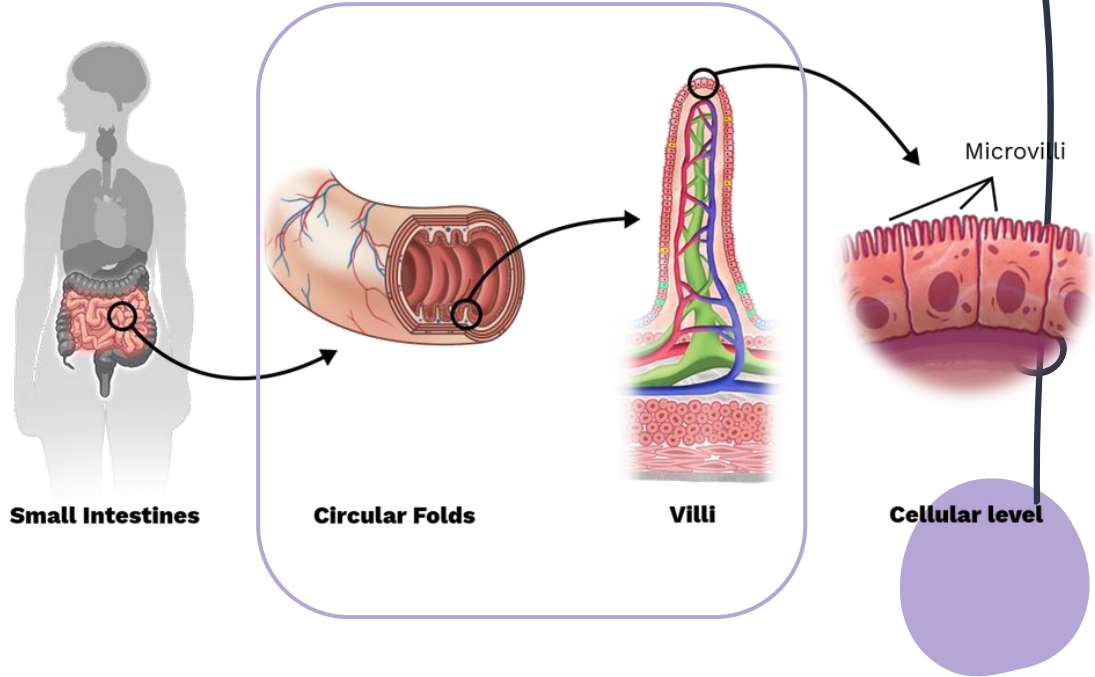
Ileum

The **majority** of nutrients are **absorbed** in the ileum

MAXIMIZING NUTRIENT ABSORPTION

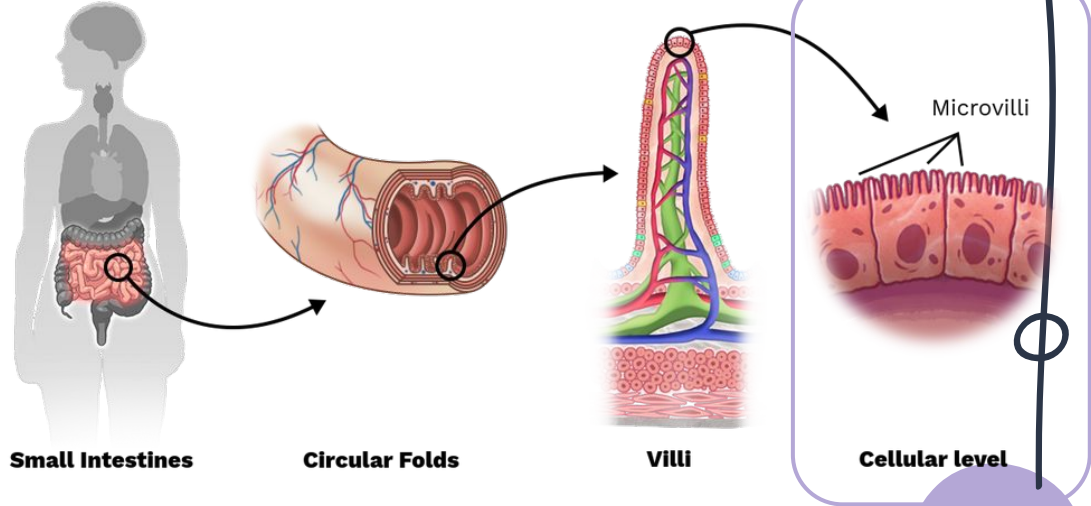
- x The inner layer of the small intestine is folded into **ridges** containing fingerlike projections (**villi**) to **maximize surface area** for nutrient absorption

- x 10X increase in SA



MAXIMIZING NUTRIENT ABSORPTION

- Furthermore, each of the single layered epithelial cells that make up the villi (singular: villus) has **even smaller**, microscopic projections of the cell membrane called **microvilli** (singular: microvillus)

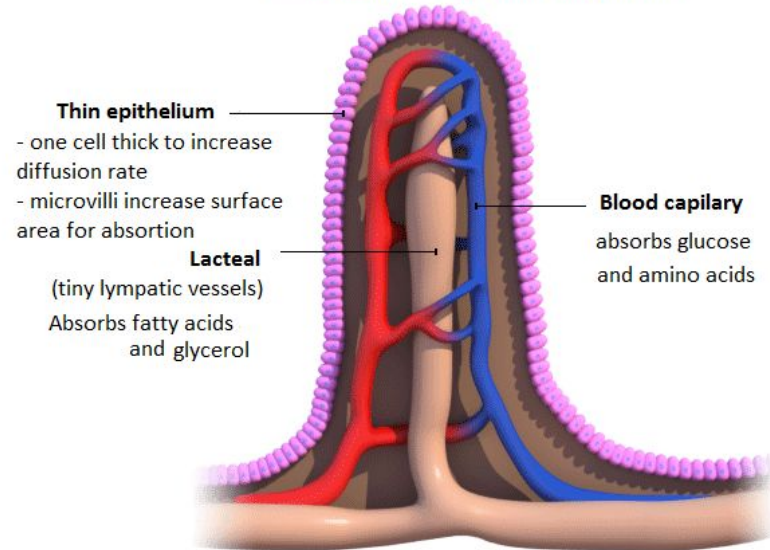


The combined effect of the villi and microvilli is estimated to increase the surface area by a factor of 500.

NUTRIENT ABSORPTION

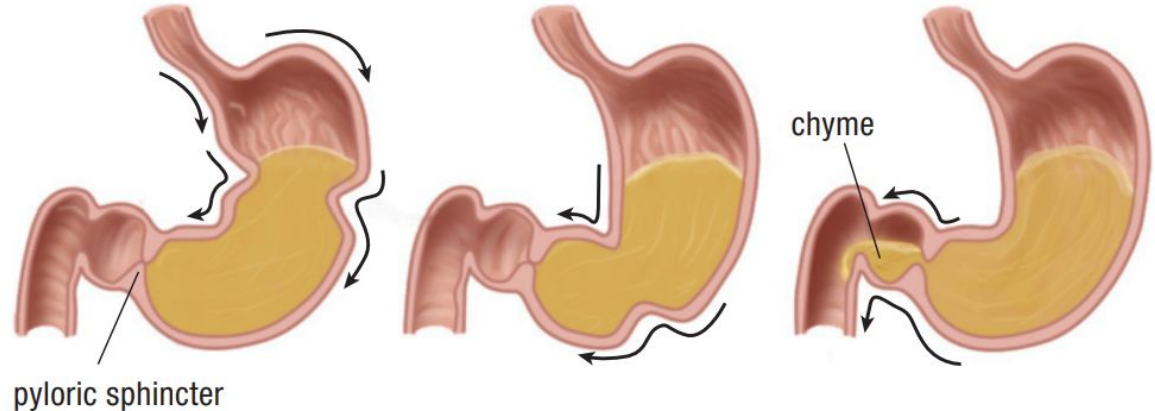
- X Within each villus is a network of tiny blood vessels called **capillaries**.
 - X All nutrients, except digested fats, enter the **bloodstream** through the **capillaries**
- X **Digested fats** are transported through small vessels called **lacteals**.
 - X The digested fats are transported into the **lymphatic system**, and from there into the **bloodstream**

Longitudinal section through a villus



FROM STOMACH TO DUODENUM

- ✗ **The pyloric sphincter** controls the movement of chyme from the stomach to the duodenum
 - ✗ Muscle relaxes periodically to allow small increments of chyme to enter so overflow is avoided





ACCESSORY ORGANS

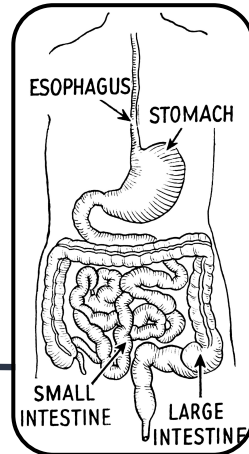


DIGESTIVE & ACCESSORY ORGANS

Digestive Organs

The **alimentary canal** is made of **digestive organs** that form a **hollow tube** (mouth to anus).

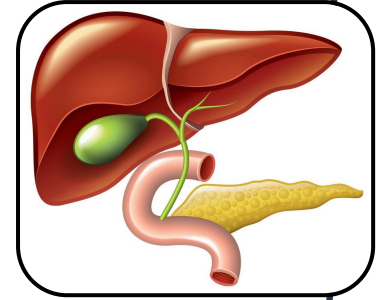
Food passes through the digestive organs.



Accessory Organs

The accessory organs **secrete fluids** into the tract that aid in digestion.

Food **does not** pass through the accessory organs.

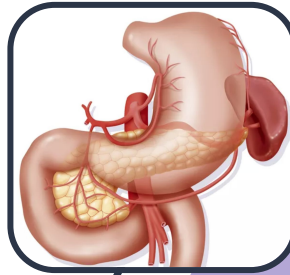




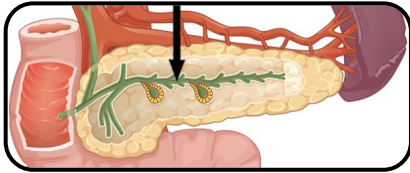
ACCESSORY ORGANS

1. Pancreas
2. Liver
3. Gallbladder

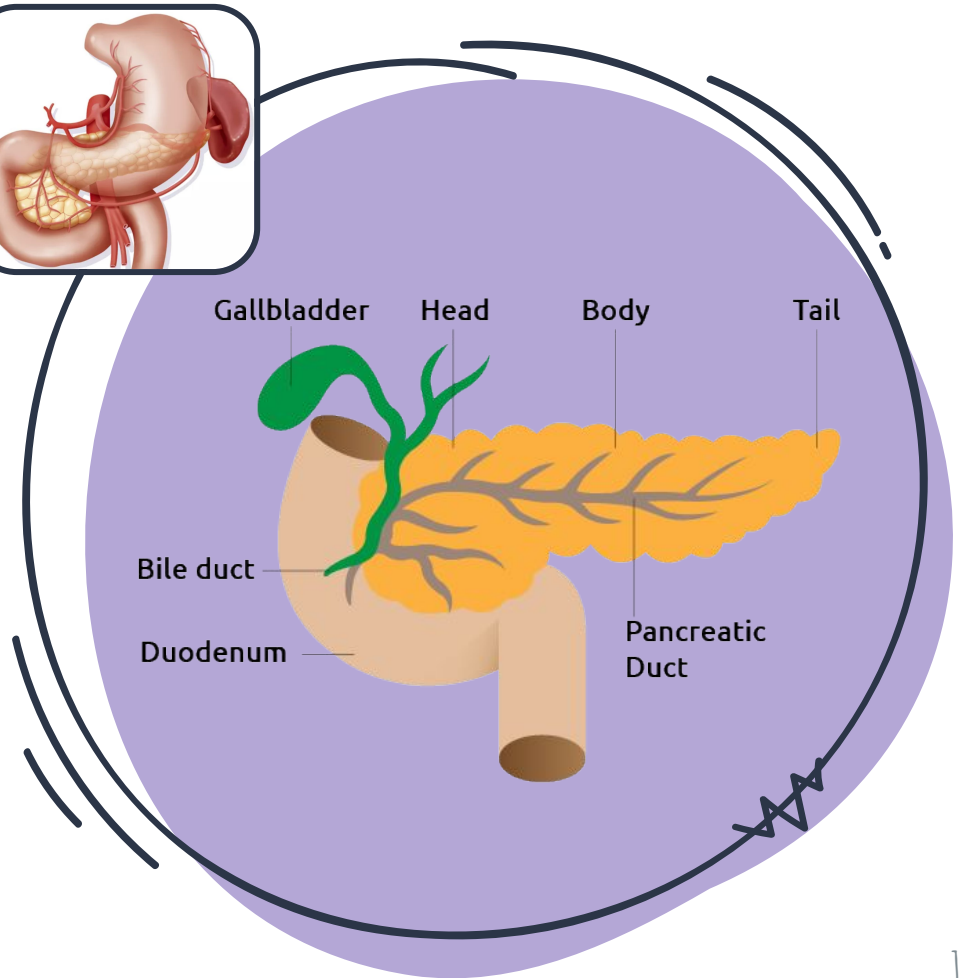
THE PANCREAS



- X Connects to the duodenum via the **pancreatic duct**



- X Spongy, elongated and tapered
- X Sits behind stomach
- X Head sits in C-part of duodenum
- X Glands produce and secrete substances into the body



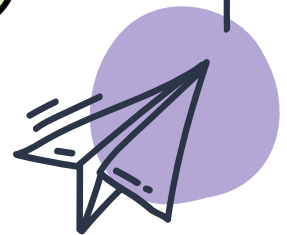
THERE ARE TWO MAIN FUNCTIONS OF THE PANCREAS

1. To secrete **pancreatic juice** (1L/day) into the tract to aid digestion

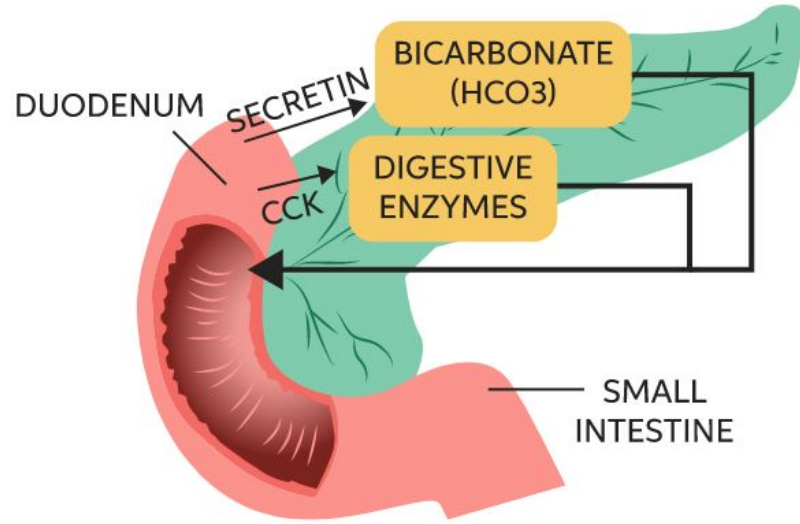
- X Water
- X Digestive enzymes
- X Bicarbonate
- X Hormones



2. To regulate blood sugar by producing and releasing the hormones insulin and glucagon



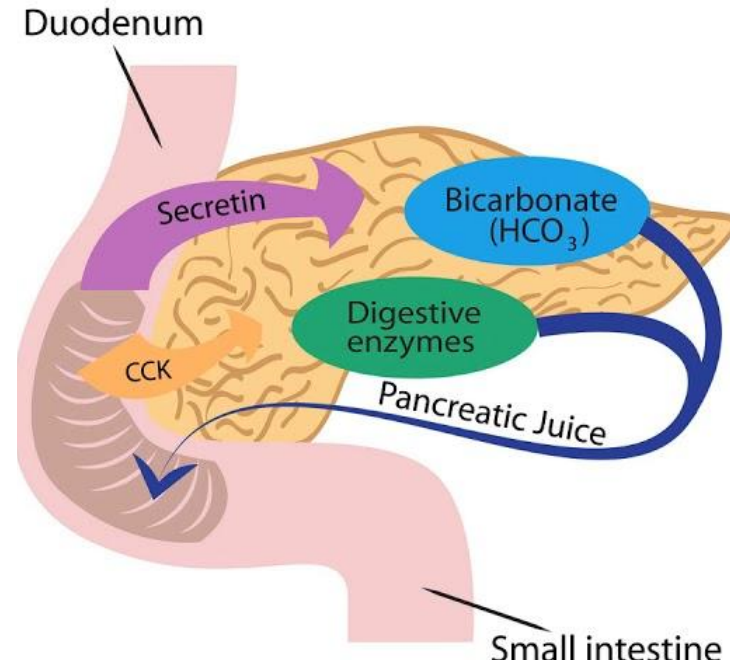
What controls the release of pancreatic juices into the small intestine?



Hormones cholecystikinin (CCK) and secretin when chyme enters duodenum

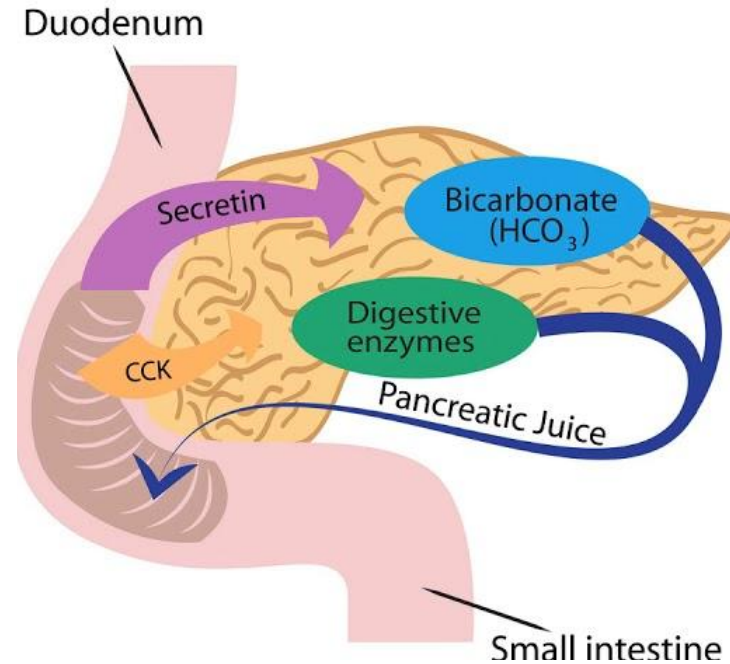
CONTROLLING PANCREAS: HORMONE CCK

- X When **fat-rich** chyme enters the duodenum, **cholecystikinin (CCK)** is secreted by special cells in the duodenum and released into the bloodstream.
- X CCK signals the pancreas to secrete a variety of substances, **including enzymes** that are needed for lipid, carbohydrate, and protein digestion.
- X CCK also signals the **stomach** to **slow down** the movement of chyme into the small intestine so that fats can be properly digested.

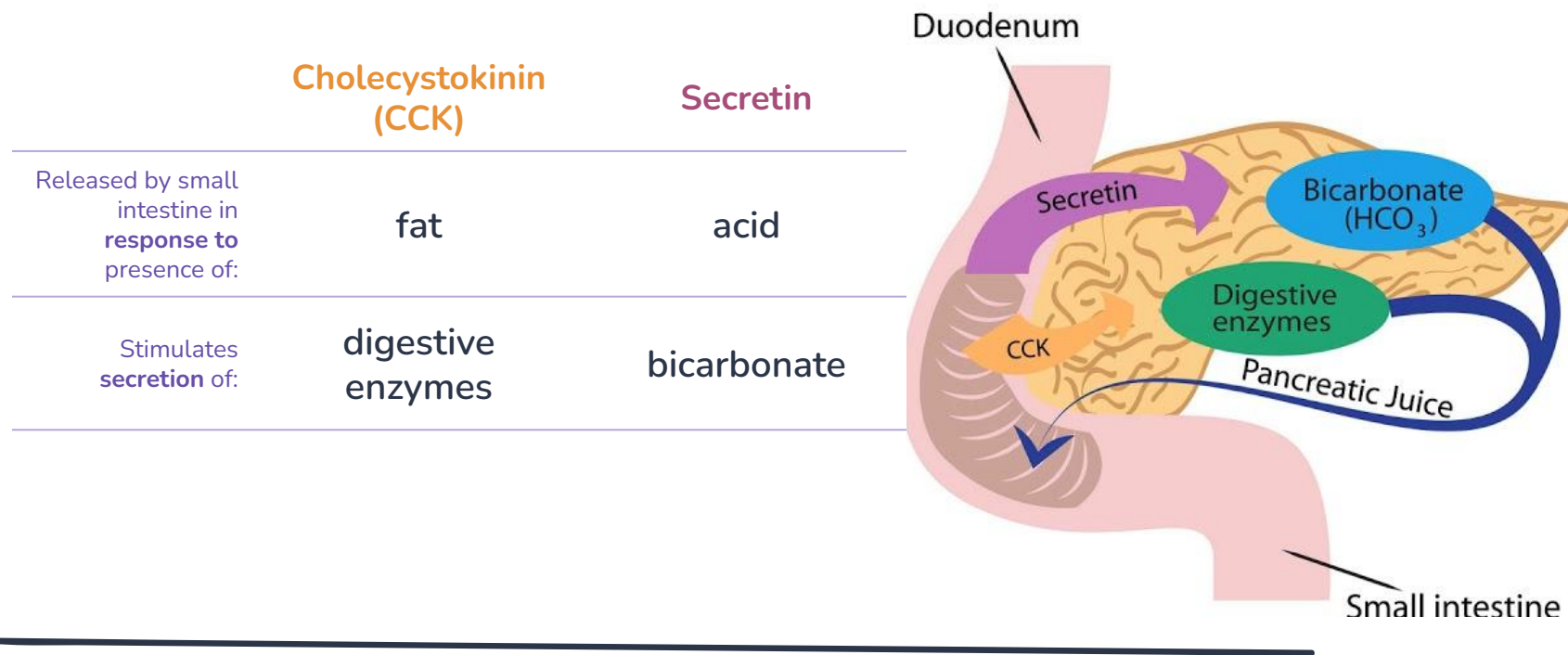


CONTROLLING PANCREAS: SECRETIN

- X The low pH of chyme (about 2.5) triggers a chemical called **prosecretin** that is present in the epithelial cells of the small intestine to be converted into its active form, **secretin**.
- X Secretin stimulates the pancreas to release **bicarbonate** ions to **neutralize** the acidic chyme and raise the pH from about pH 2.5 to **pH 9.0**.
- X Thus, secretin **protects** the small intestine from stomach acids.

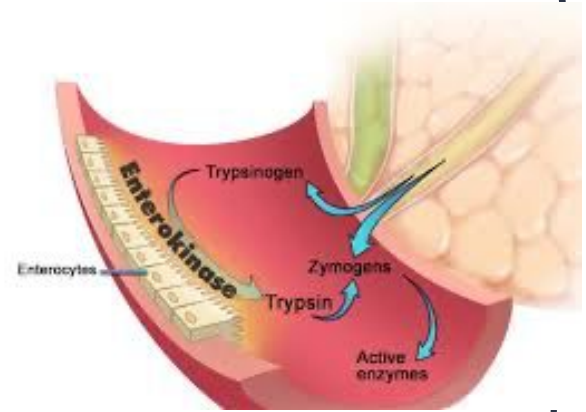


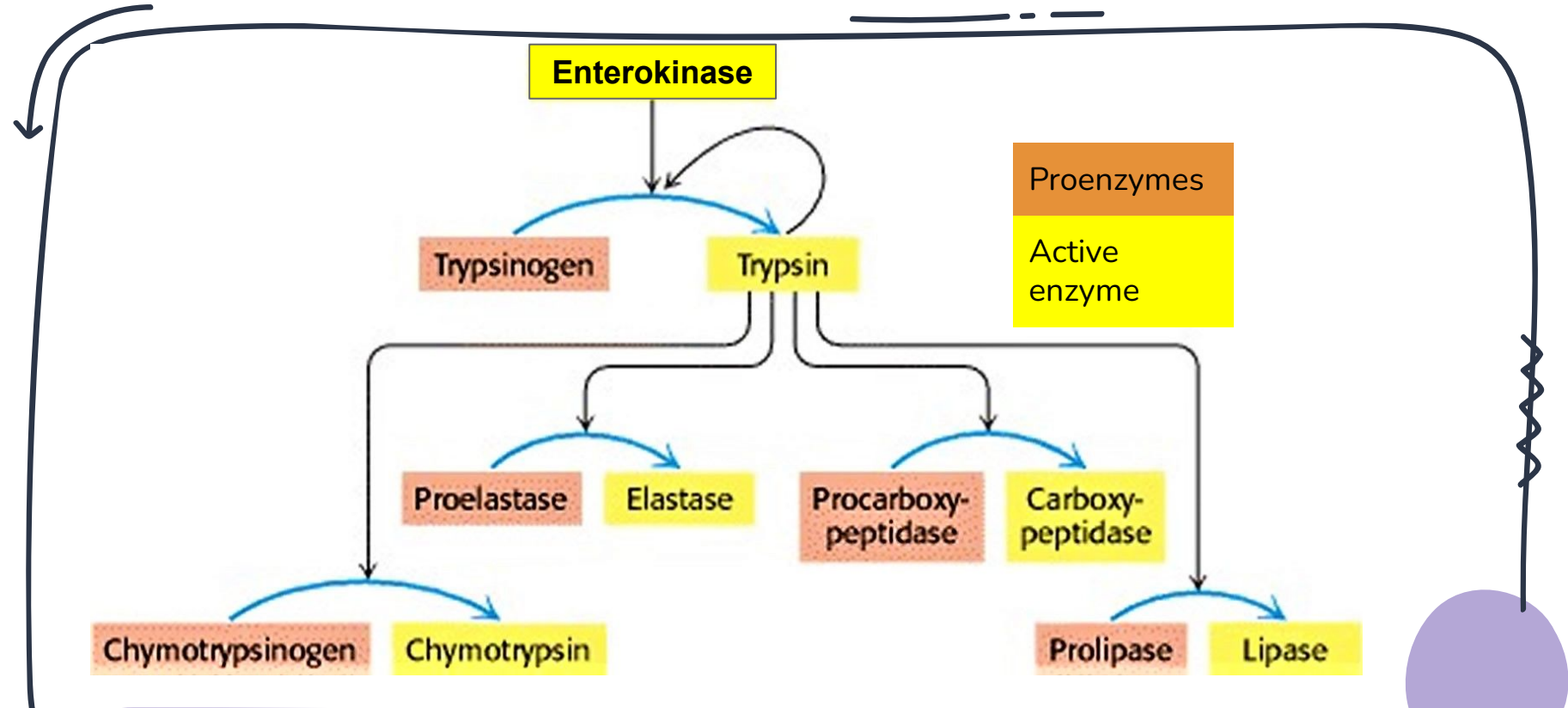
CCK AND SECRETIN OVERVIEW



DIGESTIVE ENZYMES: PROTEASE TRYPSIN

- X Recall that **pepsin** (protein digestive enzyme in stomach) is only active in acidic conditions
 - X Therefore, not active in small intestine
- X The pancreas releases **trypsinogen**, which is an inactive form of a protein-digesting enzyme called **trypsin**. The trypsinogen travels from the pancreas to the duodenum
 - X Once it reaches the duodenum, an enzyme called **enterokinase** converts it into active **trypsin**
 - X Trypsin further breaks down any partially digested proteins that remain and converts other proenzymes into their active forms

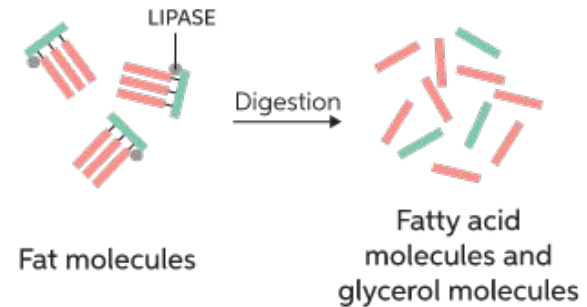




Once activated by enterokinase, trypsin breaks down large proteins and transforms other proenzymes into their active forms..

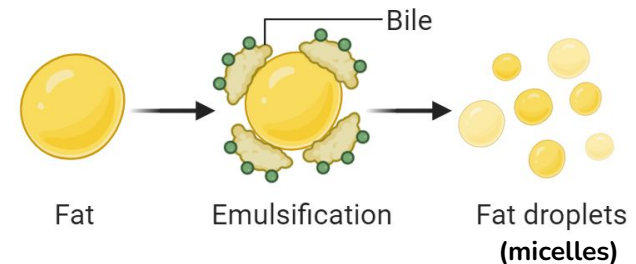
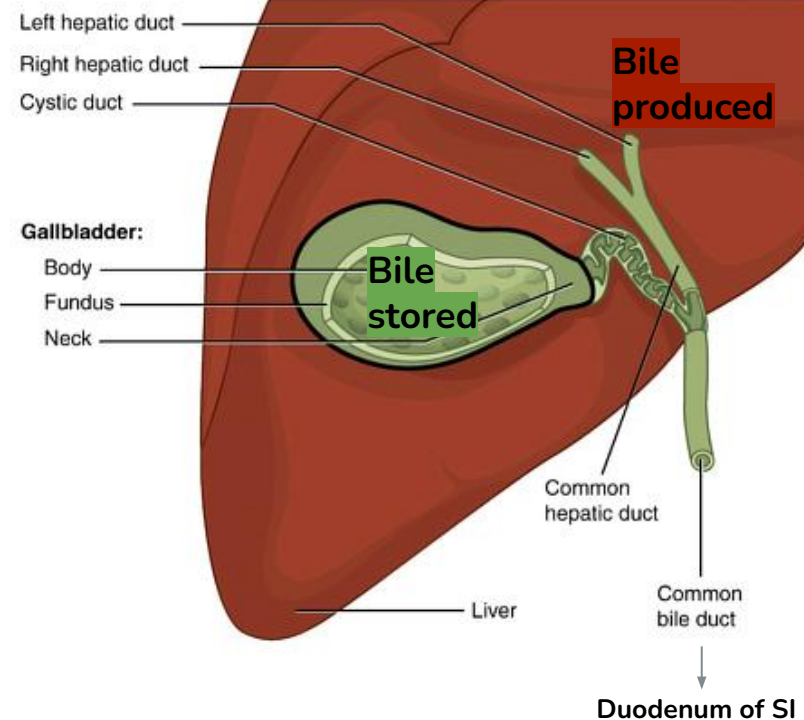
DIGESTIVE ENZYMES: LIPASES

- X Fats that enter the duodenum are subjected to the action of **lipases**
 - X Lipases are enzymes secreted by the pancreas that **break down lipids** into fatty acid molecules.
- X However, fats in chyme are present as **large globules**.
 - X Lipases cannot penetrate beyond the surface of the fat globules. The liver and its secretions (**bile**) must become involved.



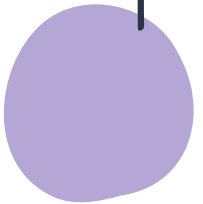
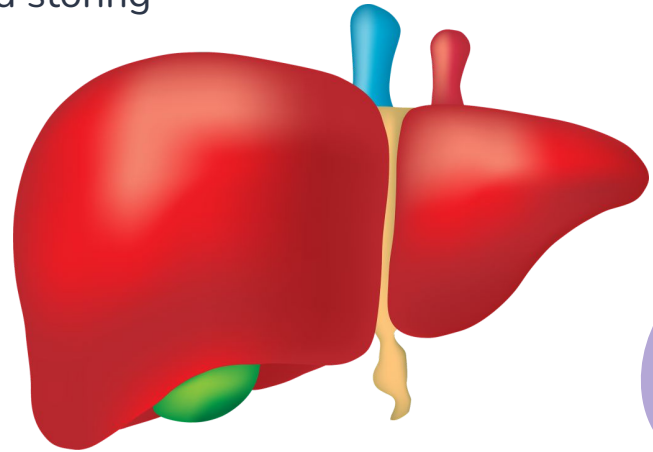
THE LIVER & GALLBLADDER

- X The **liver** produces and secretes **bile**, a substance that **emulsifies fats**, breaking them into **tiny** droplets called **micelles**
 - X This gives the **lipases** (enzyme) a much greater surface area on which to act, and the **rate** of lipid digestion **increases**
- X Bile is continuously produced in the liver, but it is **stored** in the gallbladder
 - X Bile travels to the gallbladder:
 - **Liver** → hepatic ducts (L & R) → common hepatic duct → cystic duct → **gallbladder**
 - X When **lipids are present** in the SI, bile is squeezed out of the gallbladder:
 - **Gallbladder** → cystic duct → common bile duct → **duodenum**

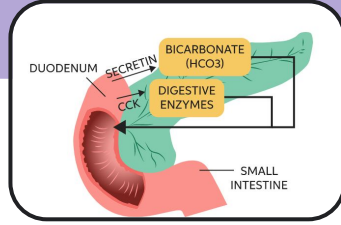


OTHER ROLES OF THE LIVER

- X The removal and breakdown of toxins, (ie. alcohol) occurs in the liver.
- X The liver is also involved in producing and storing glycogen and fat soluble vitamins.



REMEMBER THE HORMONES RELEASED WHEN CHYME ENTERS DUODENUM? (MORE FUNCTIONS)

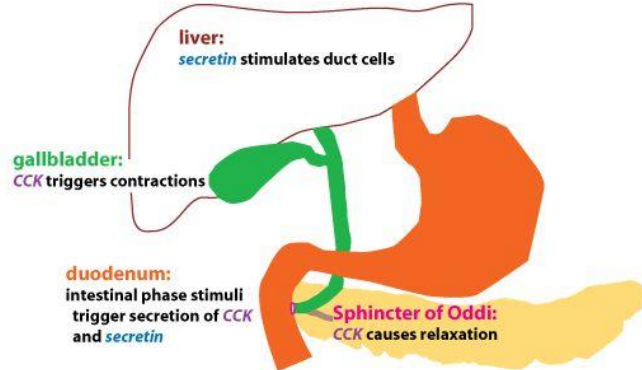


Secretin

Secretin stimulates the flow of bile from the liver to the gallbladder

CCK Cholecystokinin

CCK stimulates the **gallbladder** to contract, causing bile to be secreted into the duodenum





TRANSPORT
MECHANISMS
(IMPORTANT FOR ABSORPTION)



THE NEED FOR TRANSPORT MECHANISMS

X In order for **all cells in the body** to receive the broken down **nutrients** from the tract, substances must cross several cell membranes by **diffusion**.

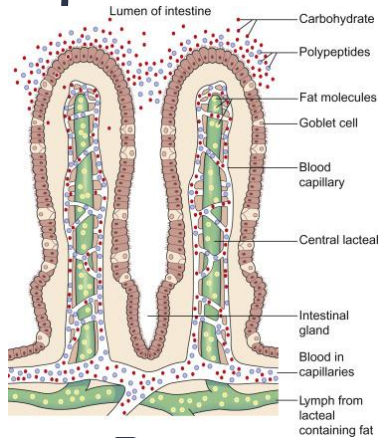


Figure A: Nutrients moving from the tract through the epithelial cells and into the capillary network (blood vessels).

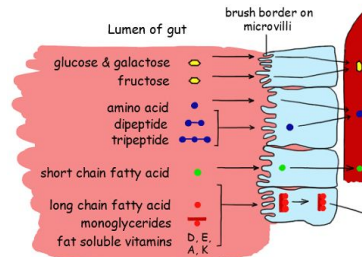


Figure B: Zoomed in version of figure A.

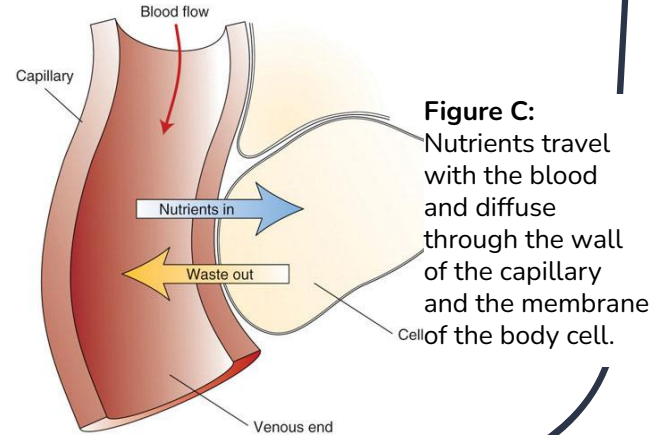
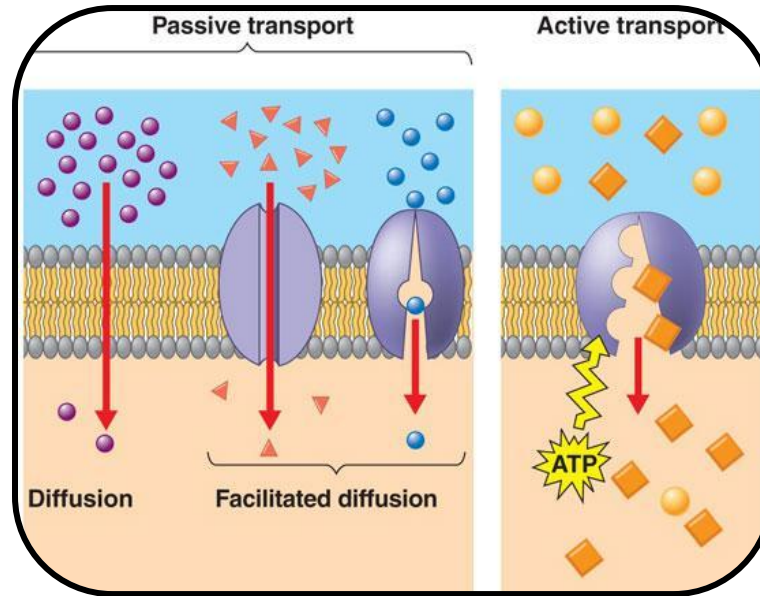


Figure C: Nutrients travel with the blood and diffuse through the wall of the capillary and the membrane of the body cell.

Mechanisms for moving substances across cell membranes



Passive Transport:

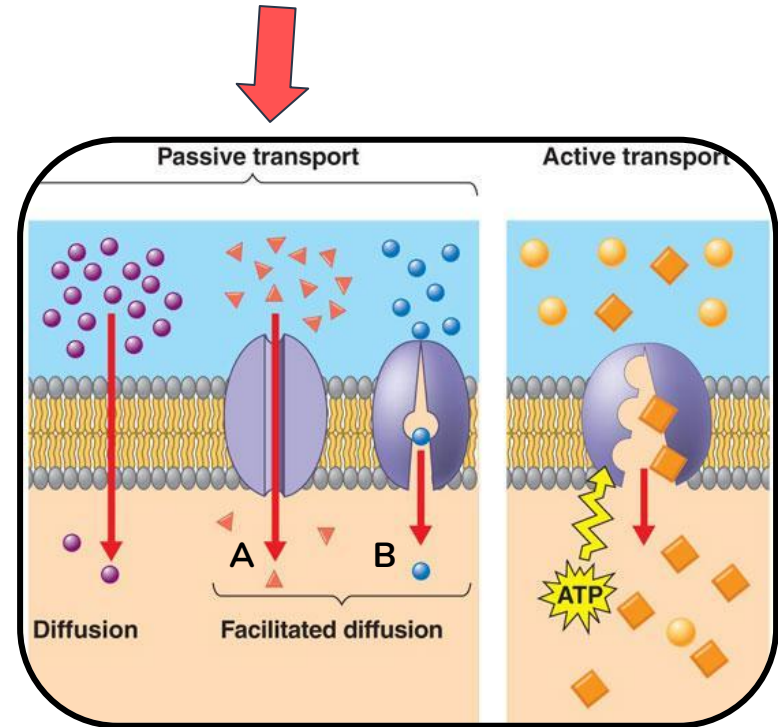
- ✗ Movement of small particles with their concentration gradient
- ✗ Particles move from area of ↑concentration → area of ↓concentration
- ✗ No energy required!

DIFFUSION

- ✗ Small particles can diffuse on their own
- ✗ “Osmosis” is the term for diffusion of water specifically

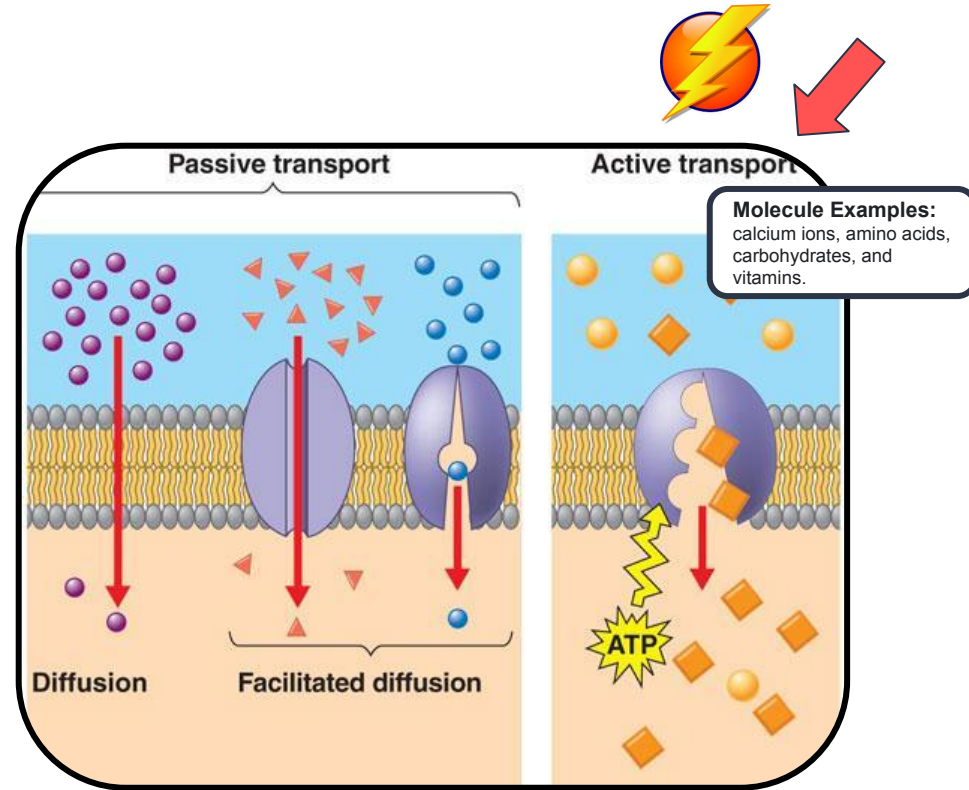
FACILITATED DIFFUSION

- ✗ Large particles require membrane proteins to facilitate their diffusion (e.g. protein channels A and B)



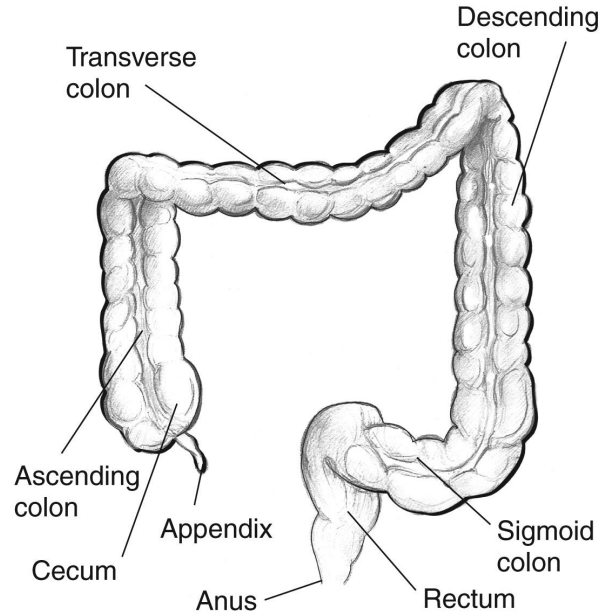
Active transport:

- X Movement of large particles against their concentration gradient
- X From area of ↓ concentration → area of ↑ concentration
- X Energy **ATP** is required
- X Transport proteins move materials across membrane



STRUCTURE OF THE LARGE INTESTINE (LI)

- X Approximately 1.5 m in length
- X Approximately 7.6 cm in diameter
 - X 2-3 times **larger in diameter** than the small intestine
- X The large intestine consists of the cecum, appendix, colon, rectum, and anus
 - X The colon is separated into four parts: ascending, transverse, descending and sigmoid



NOTE:

- The cecum is a pouch that receives processed material
- The appendix is vestigial
- The rectum is up to 20 cm long

FUNCTIONS OF THE LARGE INTESTINE

Digestion is complete and most of the nutrients, including ~90% of water, have been absorbed by the time the digested material reaches the large intestine

- x As **indigestible** material, such as **cellulose**, passes through the colon, **water** (~10%) is absorbed through the process of **osmosis**
 - x It may take 4 to 72 hrs for the undigested material to pass through the large intestine, depending on the types and volume of food eaten.
 - x Approximately **20 L** of fluids pass through the large intestine daily, and most of this is reabsorbed back into the body.
- x Vitamins B and K, and minerals, sodium (Na^+) and chloride (Cl^-) ions, are also absorbed in the LI

BACTERIA IN THE COLON

- X 500+ species of bacteria normally inhabit the LI
- X E. coli is the most common species
- X They exist in a **symbiosis**:
 - X Bacteria live in a **suitable environment** and have access to a plentiful **food** supply
 - X In return, they produce essential **vitamins** (e.g. vit K and B)
- X Another **byproduct** of bacterial action is gas— some is absorbed in the large intestine and some is released as flatulence
- X Although these bacteria are needed, some strains can create **serious** or even **fatal** problems if they enter and reproduce in the stomach or small intestine



EGESTION

- X Indigestible food such as **cellulose** and other fibers are important
 - X **Add bulk** and provides **full** feeling
 - X **Retain water** in large intestine to help in egestion

The **absorption** of water in the large intestine results in a soft solid (feces)

- If too **much** water was absorbed
→ constipation
- If too **little** water was absorbed
→ diarrhea

Nerves in wall of the large intestine detects movement of feces in rectum
→ defecation reflex activated

Defecation is controlled by two sphincter muscles in the anus

EGESTION: ANAL SPHINCTERS

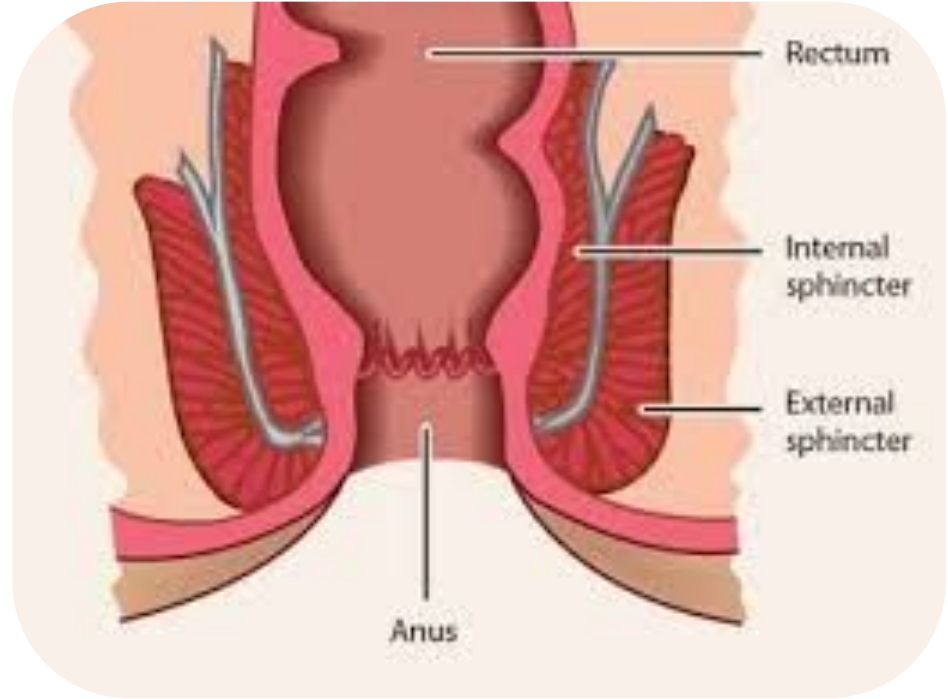
Internal sphincter

X smooth, involuntary

External sphincter

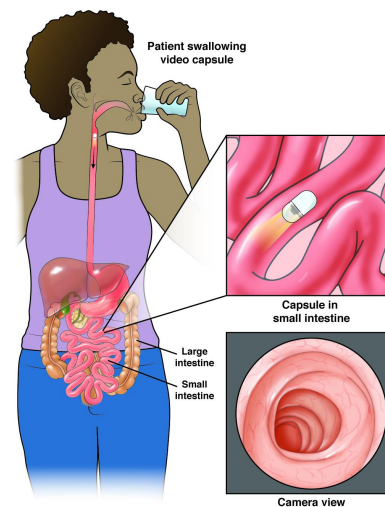
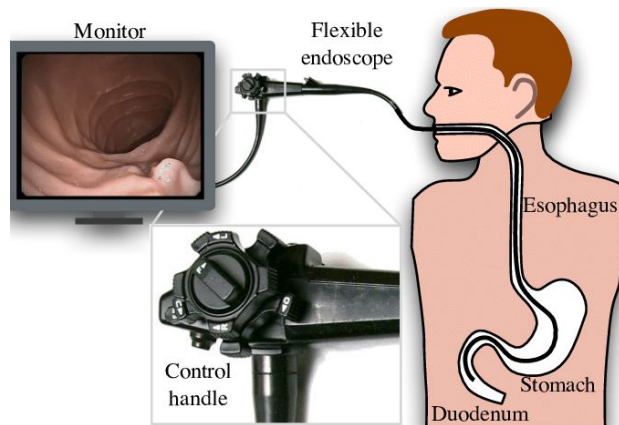
X skeletal, voluntary

Feces is eliminated when both sphincters are relaxed



ENDOSCOPE

- X Designed to look inside the body
 - X **Endoscopy:** any procedure that uses an endoscope to look inside the body
- X Narrow tube with a light source, lens, and camera for imaging
 - X Enters body through mouth, anus, or an incision
- X Different attachments can be inserted to perform different procedures including:
 - X **Biopsy:** taking a sample of tissue for examination
 - Surgery:** such as gallbladder removal



Capsule endoscopes look like a pill and can be swallowed. The capsule takes thousands of images as it makes its way down the entire tract.

SUMMARY

Homework:

P. 420 #1, 2a, 3, 7 & 8

9.5 Summary

- Most digestion takes place in the duodenum and the jejunum of the small intestine. Enzymes, hormones, and bile from the pancreas and the liver are secreted into the bloodstream or directly into the duodenum.
- The mucosa of the small intestine consists of villi and microvilli, which greatly increase the surface area for absorption.
- Absorption of nutrients occurs in the jejunum and ileum in the small intestine. Water, sodium, and chlorine ions, and some vitamins, are absorbed in the colon in the large intestine.
- Passive transport is the movement of materials across a cell membrane without the expenditure of energy by the cell. Passive transport includes diffusion, facilitated diffusion, and osmosis.
- Active transport uses the cell's own energy to move materials into or out of the cell.
- Indigestible material, such as cellulose, and other waste products are collected in the rectum and egested as feces through the anus.



DISEASES ASSOCIATED WITH THE DIGESTIVE SYSTEM

DIAGNOSING DIGESTIVE DISORDERS

Blood Tests

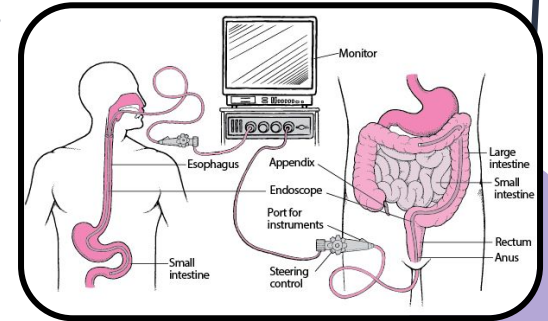


Fecal Tests



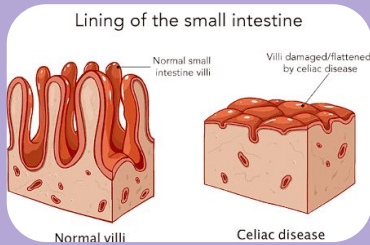
Endoscopy

Viewing the alimentary canal with a tiny camera inserted via the mouth or anus.



CELIAC DISEASE

- X Autoimmune reaction to gluten
- X Body essentially attacks gluten (considered foreign to body) causing damage to villi



- X Flattened villi negatively impact body's ability to absorb nutrients

- Celiac disease can be triggered at any point in one's lifetime
- In Canada, 1.0% of the population is affected by celiac
 - ◆ 90% of celiac disease cases remain undiagnosed.
- **Symptoms:** chronic diarrhea, abdominal distention, malabsorption, and loss of appetite.

CELIAC DISEASE TREATMENT

Dr. Axel
FOOD & MEDICINE



FOLLOW A STRICT GLUTEN-FREE DIET

A lifelong adherence to a strict gluten-free diet will allow the immune system to repair itself, which will keep symptoms from flaring up.



CORRECT ANY NUTRIENT DEFICIENCIES

Talk to your doctor about performing tests to confirm any deficiencies, then take quality supplements to help speed up the healing process and fill in any gaps.

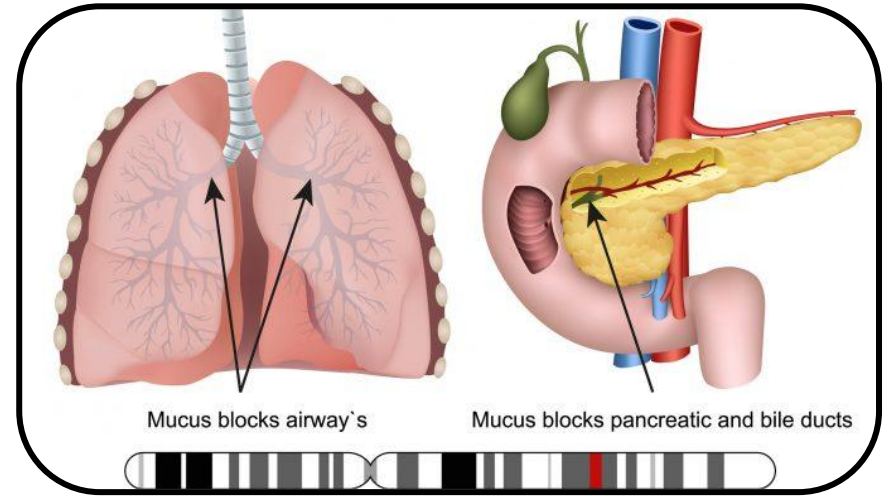


CONSIDER ADDITIONAL TESTS DONE TO CHECK BONES, SKIN AND JOINTS

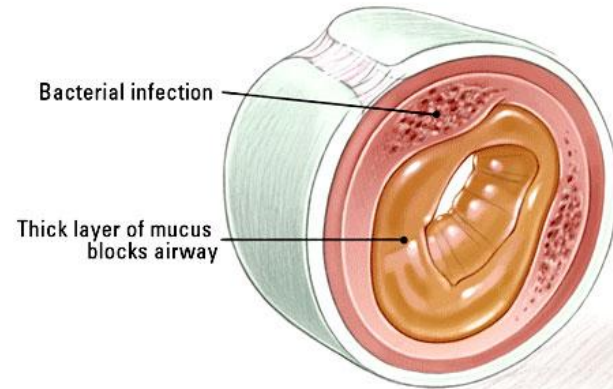
Some doctors will order a bone density test or other tests to determine if deficiencies have caused problems like bone loss or joint inflammation.

CYSTIC FIBROSIS

- X Mucus clogs the pancreas
- X Digestive enzymes are not able to get to the duodenum
- X Food is improperly digested and absorbed (especially lipids and proteins)
- X Can lead to malnutrition
- X Individuals must take replacement enzymes

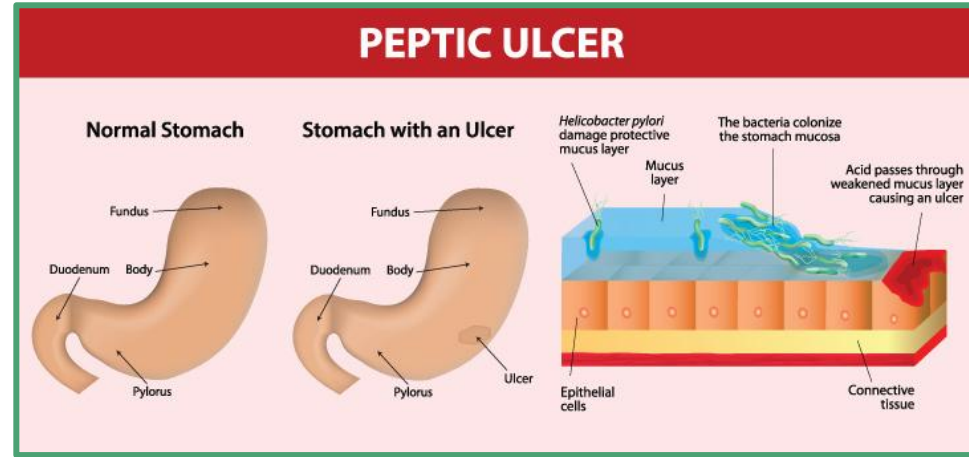
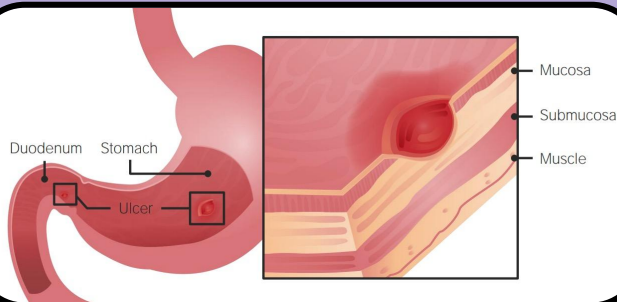


Airway with CF



PEPTIC ULCER

- X A sore in the lining of the stomach or duodenum
- X Most common cause: **Helicobacter pylori** bacteria damaging **protective mucous layer** surrounding epithelial cells
- X Acid reaches stomach lining and forms a sore

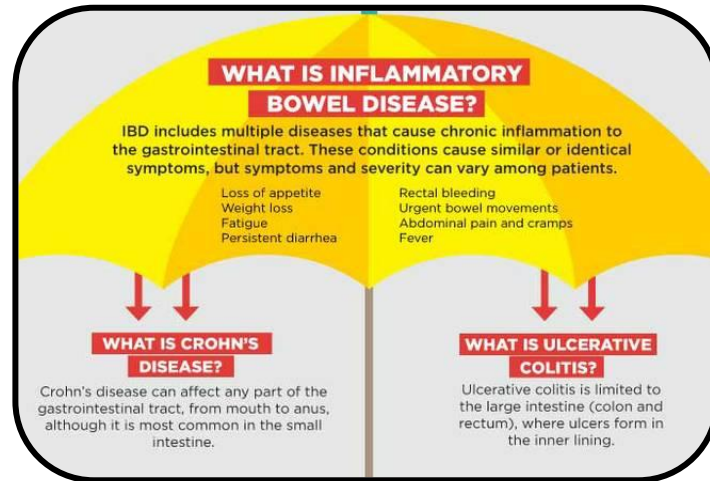


Symptoms

- Feeling bloated/full → Loss of weight
- Nausea and vomiting (vomiting blood potentially)
- Dark/black coloured stool (as a result of bleeding)
- **2-10% perforate** - hole could lead to bacteria entering the abdomen and possibly to **sepsis**

INFLAMMATORY BOWEL DISEASE:

the umbrella term for a group of diseases that cause inflammation (swelling) of the intestines.



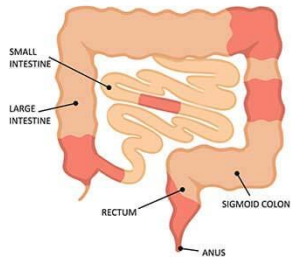
CROHN'S DISEASE

- X Inflammatory bowel disease (IBD)
- X Causes inflammation of the digestive tract
- X Decreases absorptive area

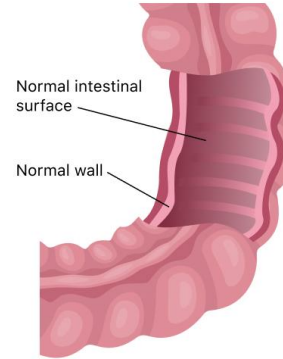
Symptoms of IBD Sufferers

- Abdominal pain
- Mouth/stomach ulcers
- Diarrhea
- Rectal bleeding
- Loss/change in appetite
- Fever
- Weight loss
- Fatigue
- Change/loss of menstrual cycle

PATCHY INFLAMMATION THROUGHOUT SMALL AND LARGE BOWEL



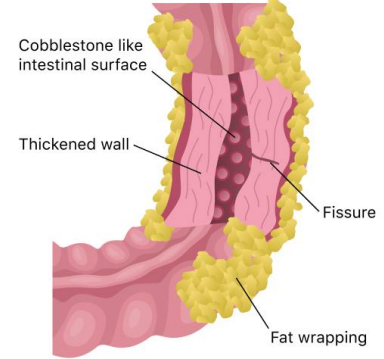
Normal Intestine



Normal intestinal surface

Normal wall

Crohn's Disease



Cobblestone like intestinal surface

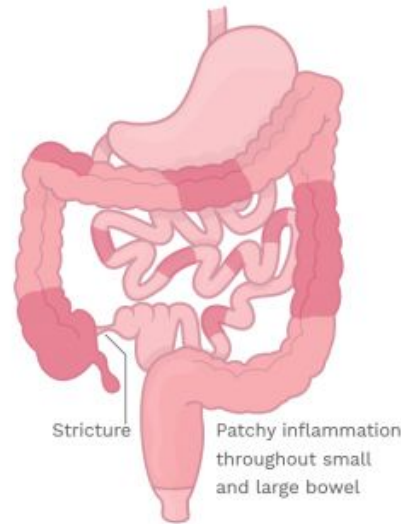
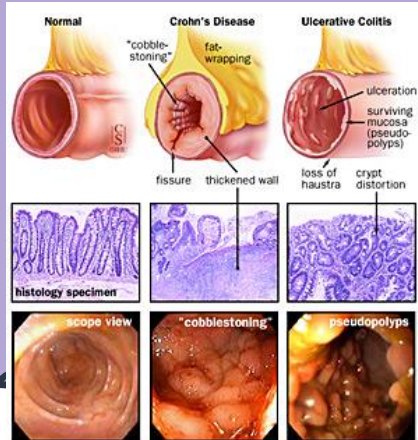
Thickened wall

Fissure

Fat wrapping

ULCERATIVE COLITIS

- X A form of inflammatory disease that attacks the **colon (large intestine)**
- X Causes inflammation
- X Decreases absorptive area
- X Ulcers form instead of fissures



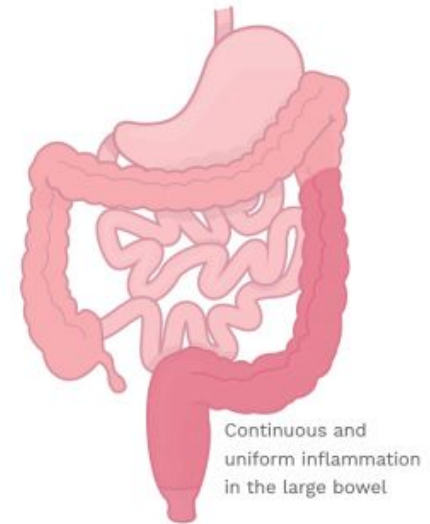
Crohn's Disease

Age of onset: 15–35 years and 55–70 years

Symptoms: Depends on location of disease. May include abdominal pain, diarrhea, weight loss and fatigue.

Bloody stool: Variable

Malnutrition: Common



Ulcerative Colitis

Age of onset: 15–35 years and 55–70 years

Symptoms: May include stool urgency, fatigue, increased bowel movements, mucous in stool, nocturnal bowel movements and abdominal pain.

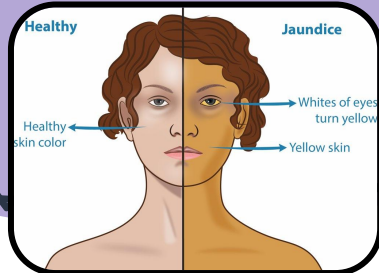
Bloody stool: Common

Malnutrition: Less common

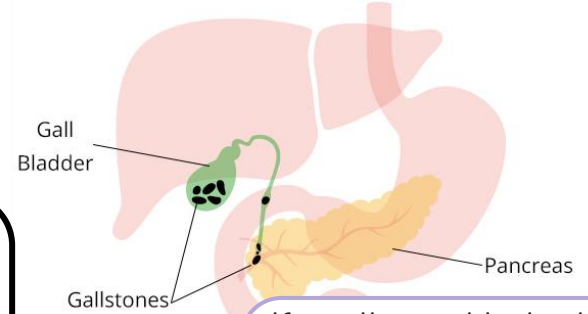
That's partly because UC affects only your colon (large intestine) and rectum.

GALLSTONES

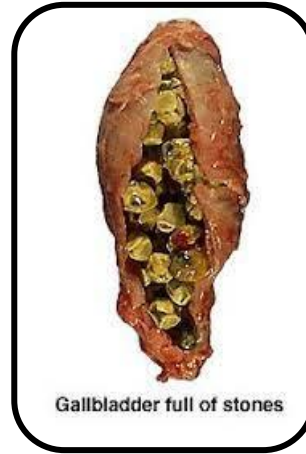
- X Cholesterol in the bile precipitates out and forms **crystals** that become **gallstones**
- X Risk factors include obesity, high cholesterol intake, and heredity.
- X If a gallstone gets stuck in the **bile duct**, it may block the passage of bile into the intestine. Bile will then seep into the bloodstream → **jaundice**



GALLSTONE PANCREATITIS



If a gallstone blocks the pancreatic duct it may cause **pancreatitis** (very painful inflammation of the pancreas).

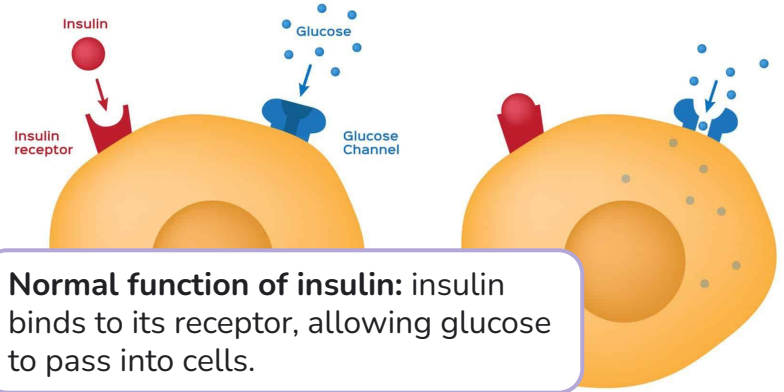


Treatment:

- Medications
- Ultrasound shock waves (to disintegrate stones)
- Gallbladder removal (can survive without one - bile will go directly to small intestine)

DIABETES

- x **Insulin** is a hormone released by the pancreas to allow glucose to enter the body's cells
- x Individuals with diabetes either
 - 1) do not produce enough insulin or
 - 2) cannot use insulin properly
- x **Problem** - Not enough sugar is delivered to cells. Sugar (chemical energy) is needed for ATP production!



Types of Diabetes

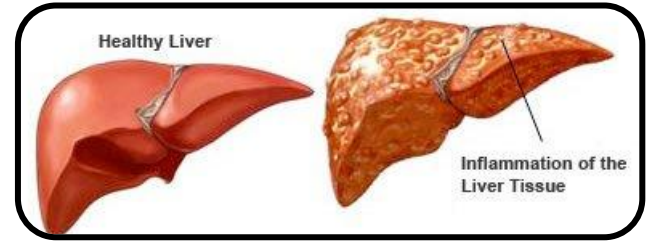
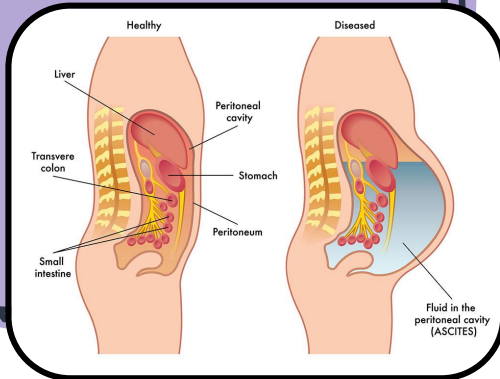
Type 1	Immune system destroys insulin producing cells in pancreas. <ul style="list-style-type: none">• Hereditary.
Type 2	Not enough insulin, or unable to use insulin properly. <ul style="list-style-type: none">• Due to high sugar diets and/or obesity
Gestational	Occurs in women in pregnancy due to fluctuating hormones and insulin levels.

Treatment:

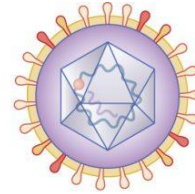
- Carefully monitoring diet & blood sugar levels
- Insulin injections

HEPATITIS

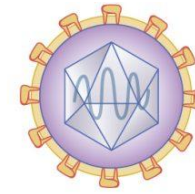
- x This is a disease that causes inflammation of the liver resulting from viral infection
- x Hinders liver's ability to produce bile
 - x Difficult to digest fatty foods
- x Build up of fluid in stomach (ascites) causes pain



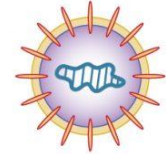
Hepatitis A



Hepatitis B



Hepatitis C



Hepatitis D



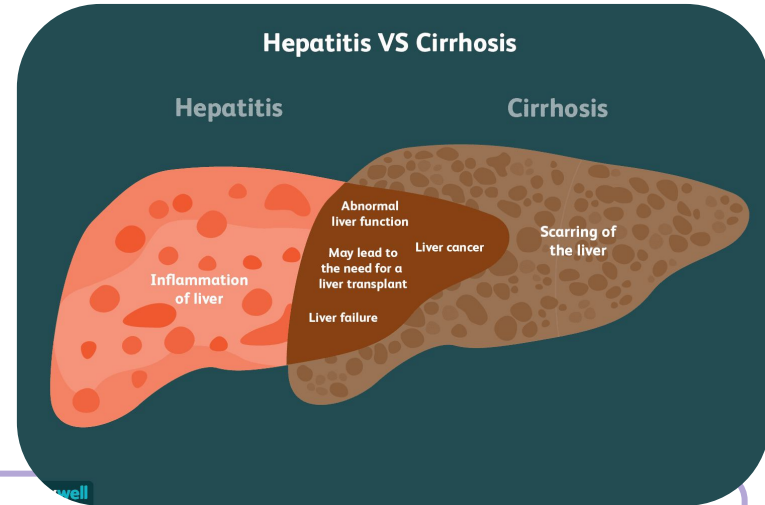
Hepatitis E

Types of Hepatitis

Type A	Contracted from contaminated drinking water or food.
Type B	Contracted through contact with a bodily fluid of an infected person.
Type C	Contracted through contact with blood from an infected person.

CIRRHOSIS

- X The liver is the only organ that can regenerate itself.
- X The healthy tissue within the liver is replaced with scar tissue.
 - X Scar tissue prevents blood from flowing and slows liver's ability to filter nutrients and remove toxins
 - X Damage to liver is irreversible
- X Caused by hepatitis and alcoholism

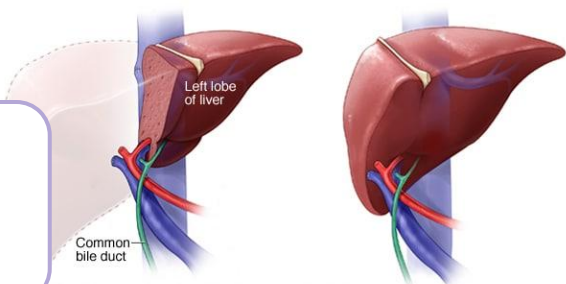


Treatment:

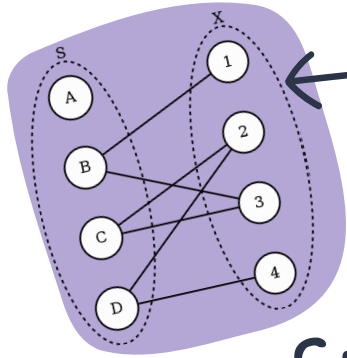
→ Transplantation of the liver, if possible

Donor liver immediately after donation

Donor liver two months after donation



Cool fact - You can donate a part of your liver while you're alive. It is the only organ that can **regenerate itself**.



CREATE A MATCHING QUESTION

to test a peer on the digestive disease
learned today.