Grade 11 Biology

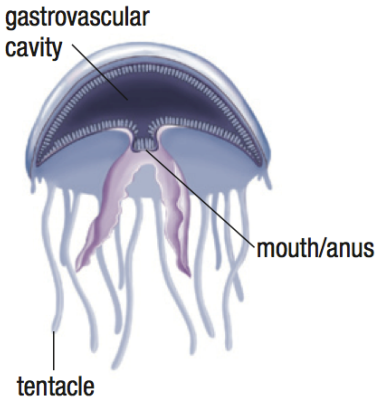
Animals – Structure and Function

Class 11

Digestive System

- Food is digested and nutrients are absorbed and transported by the circulatory system to the cells of the body
- Main Steps:
  - Ingestion – taking in of nutrients
  - Digestion – physical and chemical breakdown of food molecules into smaller molecules
  - Absorption – transfer of digested nutrients into the bloodstream
  - Egestion – removal of waste food materials from the body

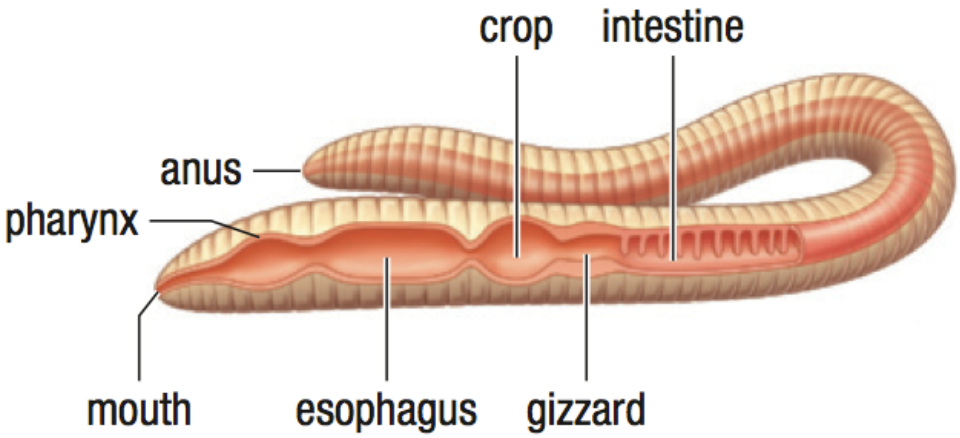
Simple Animals



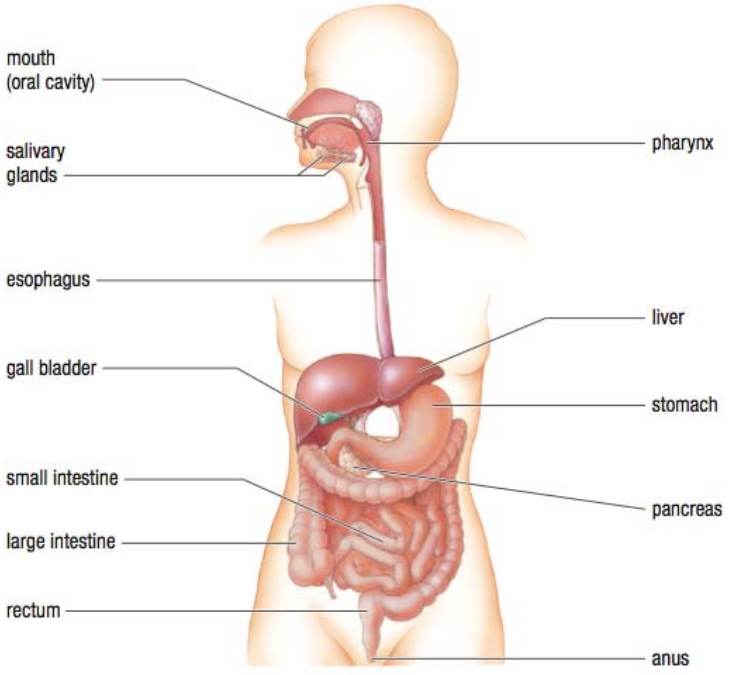
- Simple animals such as flatworms or jellyfish have a digestive sac with a single opening into a gastrovascular cavity
- Serves as both an entrance and exit for food and waste materials

Complex Animals

- Complex animals have a digestive tract with two openings – one for food intake and one for waste elimination
- In the earthworm, food is pushed down the esophagus into a crop for storage
- Gizzard helps with physical breakdown of food where food is further broken down into smaller molecules and absorbed by the intestine



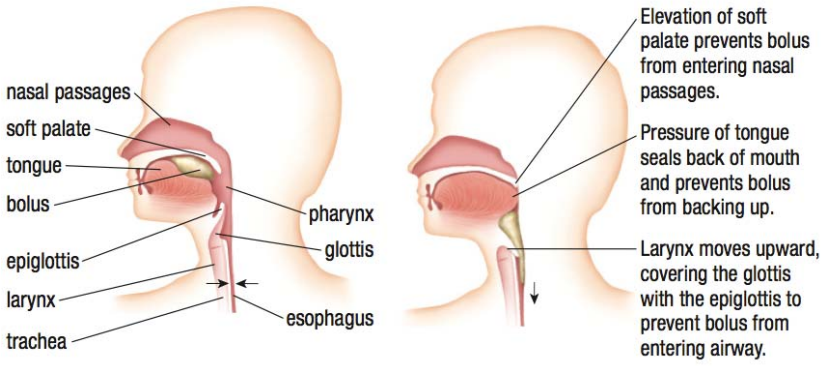
Human Digestive System

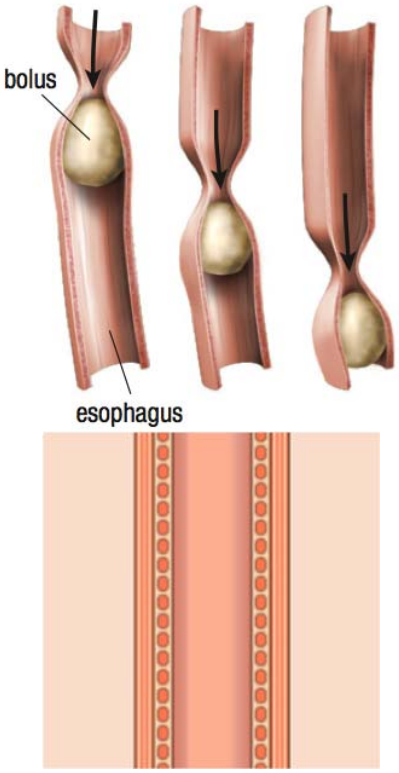


Mouth

- Digestion begins in the mouth
- Teeth help in physical digestion
  - Incisors and canines grab and cut food
  - Molars for grinding and crushing food
- Salivary glands secrete saliva which contains amylase which breaks down starch into smaller disaccharides (chemical digestion)
- Saliva contains mucous to lubricate food and make it into a bolus for swallowing

- Tongue pushes bolus back where it is swallowed
- Soft palate is raised to prevent food from entering the nasal passage
- Larynx is raised against a flap called the epiglottis to prevent food from entering the lungs



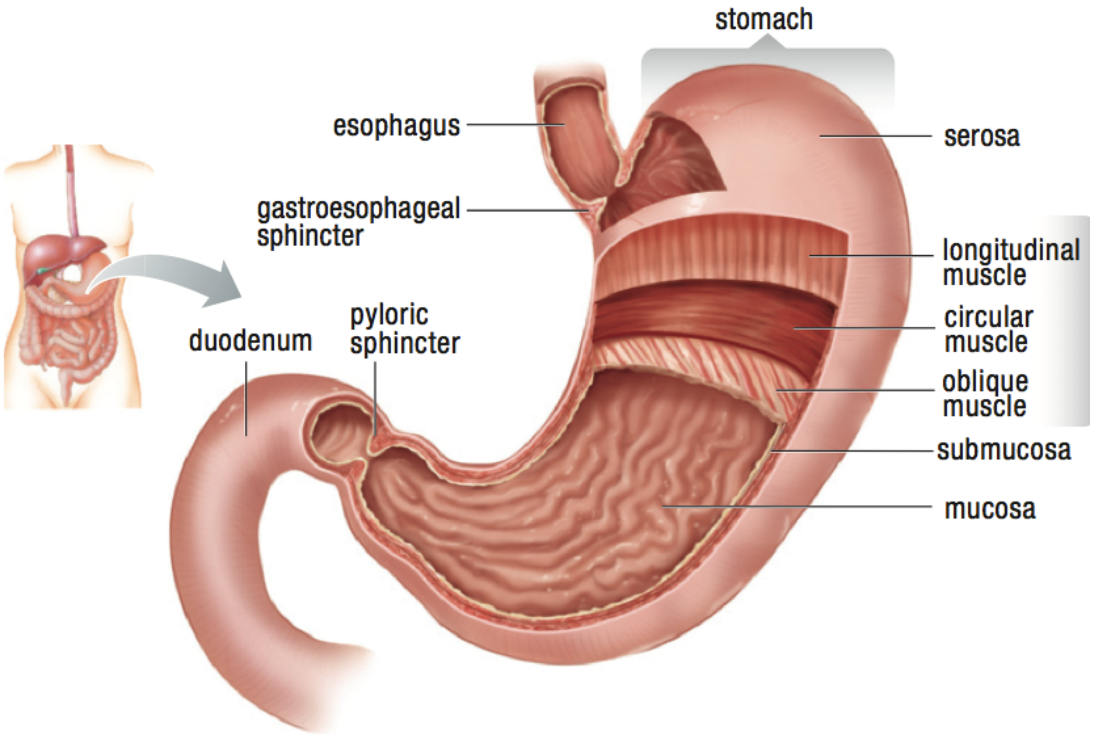


Esophagus

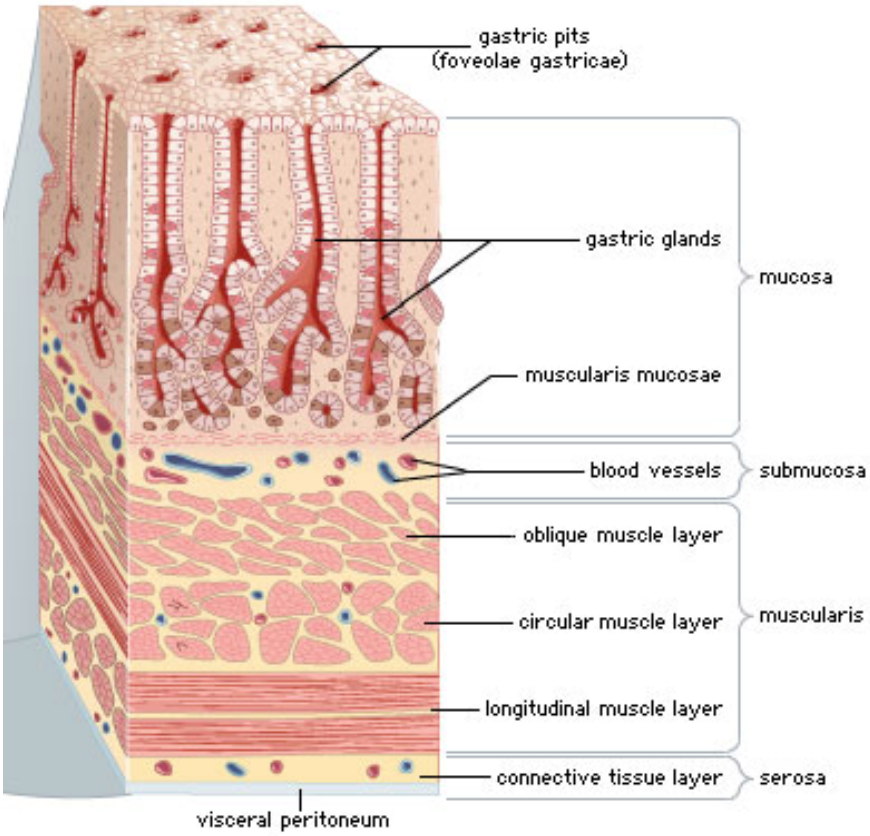
- Bolus moves down through the esophagus, a long muscular tube
- Esophagus undergoes rhythmic, wave-like contractions called peristalsis to move bolus into the stomach

Stomach

- Muscular organ that continues mechanical and chemical digestion
- Can expand to 2L of food
- Proteins are partly digested in the stomach; lipids and carbohydrates are not digested in the stomach
- Gastroesophageal sphincter separates the esophagus and the stomach to prevent food from moving back to the esophagus



- Stomach has four layers:
  - Mucosa
    - Innermost layer secretes gastric juice like digestive enzymes, acid and mucous
    - Epithelial cells in the mucosa divide rapidly to heal damage from acid
    - Replaces itself every 3 days
  - Submucosa
    - Contains networks of nerves and blood vessels
  - Muscularis
    - Contains smooth muscles that churn and mix food with gastric juices to produce chyme
  - Serosa
    - Smooth outermost layer that secretes a fluid to eliminate friction between organs



Chemical Digestion in the Stomach

- Nerves in the submucosa detect when food is present and initiate the release of a hormone called gastrin
- Gastrin stimulates the release of gastric juice (up to 2L per day)
- Acid in gastric juices has a pH of 2.0-3.0 which kills microorganisms injected with food
- Low pH activates pepsinogen to convert to pepsin to breakdown proteins into smaller proteins

Acid Reflux (Heartburn)

- Gastroesophageal sphincter does not close, causing stomach acid to enter the esophagus
- Causes a burning sensation in the lower throat known as heartburn
- An overfilled stomach can cause acid reflux
- Smoking relaxes the gastroesophageal sphincter and stimulates acid production in the stomach

Stomach Ulcers

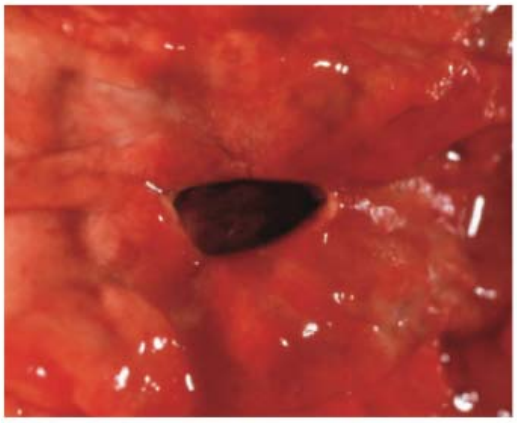


Figure 5 A break in the mucosal layer can result in an ulcer.

- Ulcer – a lesion or open sore on the epithelium of an organ
- Ulcers can bleed, cause pain and if bacteria enters the bloodstream, it can produce an infection throughout the body

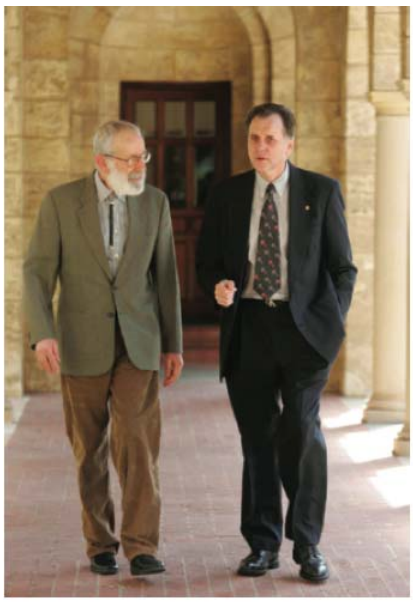
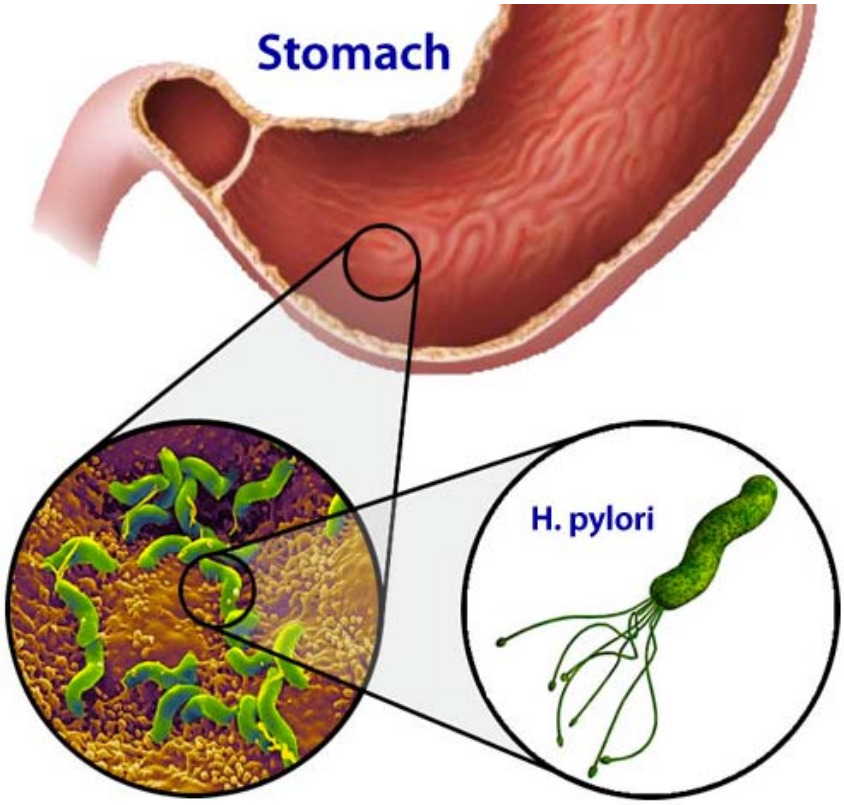


Figure 6 Dr. Robin Warren, left, and Dr. Barry Marshall, nicknamed "the guinea pig doctor," changed our understanding of the causes and treatments of ulcers.

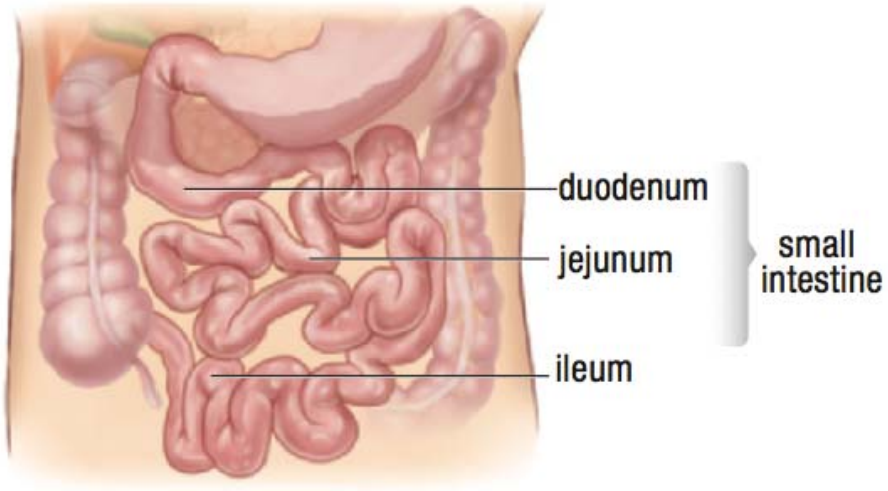
- Ulcers were thought to be caused by stress and eating spicy foods
- Dr. Warren and Dr. Marshall found *Heliobacter pylori* bacteria in the stomach of ulcer patients
- Dr. Marshall drank a solution of *H. pylori* and developed the same symptoms as ulcer patients
- He successfully treated himself with antibiotics



- *H. pylori* is able to survive the acidic environment of the stomach by secreting acid-neutralizing enzymes and burrowing through the mucosa
- Prevent mucous-producing cells from producing enough mucous to protect the stomach lining
- *H. pylori* is transmitted through food or water and saliva of ulcer patients

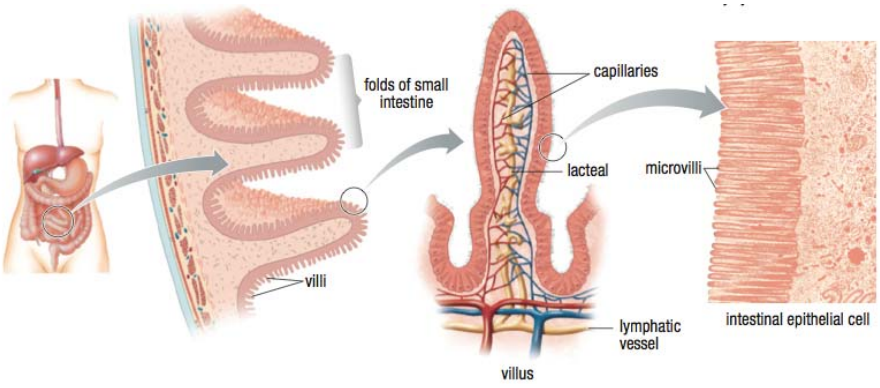
Small Intestine

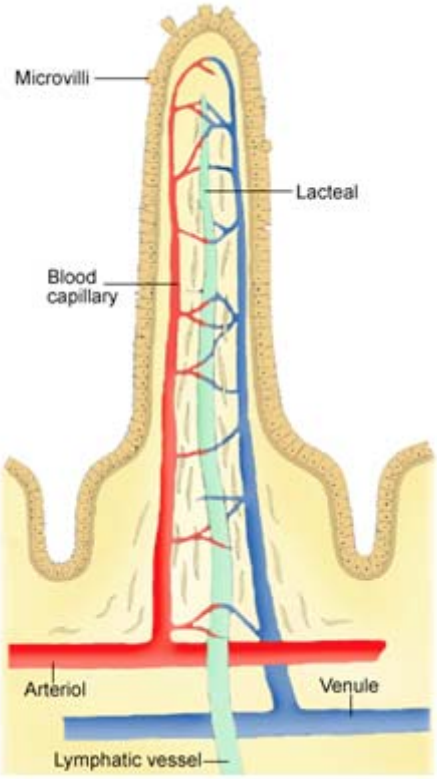
- Long tube that can be up to 7m in length
- Lipids, carbohydrates and any remaining proteins are digested
- Three sections:
  - Duodenum – where most enzymes are added and digested
  - Jejunum – digestion continues and some nutrients are absorbed
  - Ileum – main site of absorption



- No clear division between the jejunum and ileum although cells can be distinguished by their shapes in the epithelium

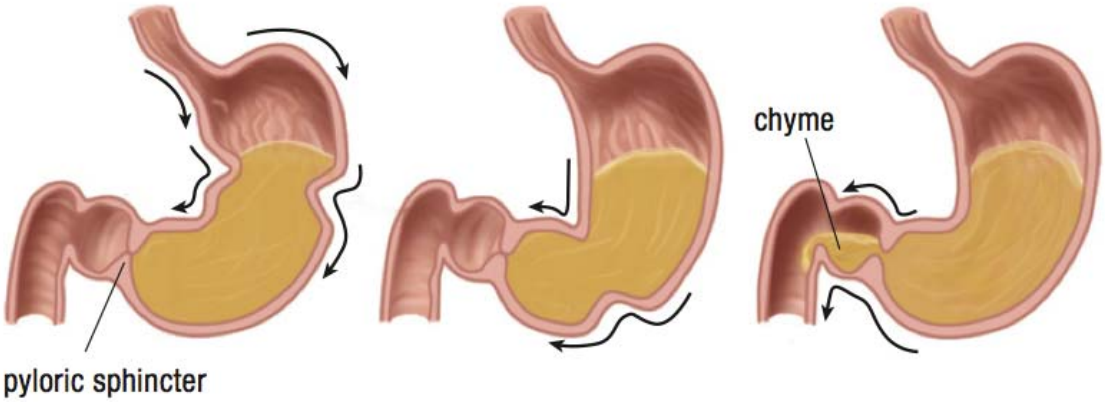
- Inner layer of small intestine is folded into ridges and contain villi
- Villi – small finger-like projections to increase the surface area by 10X
- Each villus has microscopic projections called microvilli to increase the surface area by 50X





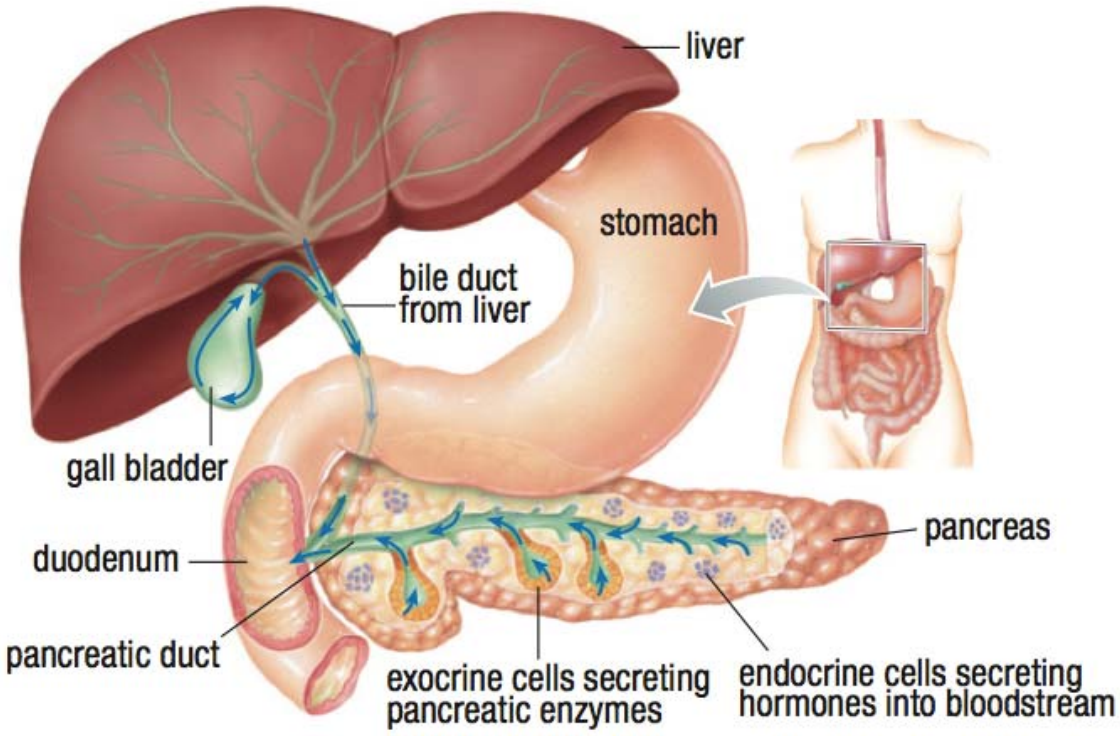
- Each villus has a network of capillaries which allows diffusion of nutrients
- Fats are transported through lacteals and moves into the lymphatic system and the bloodstream

- Pyloric sphincter controls the passage of food from the stomach into the small intestine
- Release small portions of chyme at a time into the duodenum to allow time for chemical digestion



Pancreas

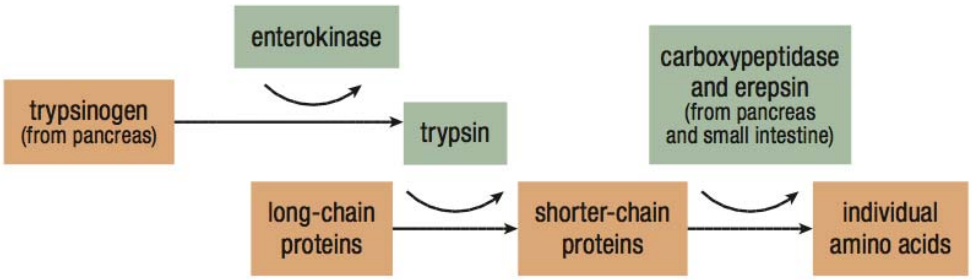
- Pancreas is a long, flat gland between stomach and duodenum
- Functions
  - Secretes enzymes for digestive process
  - Secretes hormones to regulate the absorption of glucose from the blood



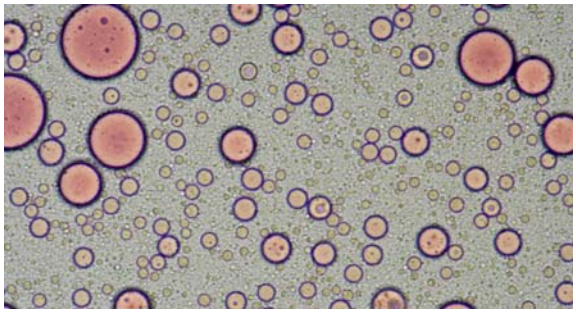
- Pancreatic amylase release to digest carbohydrates
- Cholecystokinin (CCK) hormone is released by the duodenum when fat-rich chyme enters; signals pancreas to release:
  - Substances that control the intestinal pH
  - Enzymes for the digestion of lipids, carbohydrates and proteins
- CCK also signals stomach to slow down the speed of digestion so that small intestine can digest fats

- Chyme that enters the duodenum has a pH of 2.5
- Prosecretin in the epithelial cells of the small intestine converts to secretin to stimulate the pancreas to release bicarbonate ions to neutralize the acidity
- Secretin raises the pH to 9.0
- Under basic conditions, pepsin from the stomach is inactivated to protect the small intestine from stomach acids

- Pancreas also releases trypsinogen which is converted into trypsin by an enzyme called enterokinase
- Trypsin continues to breakdown proteins into shorter proteins
- Other enzymes like carboxypeptidase and erepsin break down into amino acids



- Lipases are enzymes released by the pancreas to break down lipids
- Fats in chyme are present in large globules
- Lipases cannot penetrate beyond the surface of the fat globules
- Liver makes bile to help break down large fat globules into smaller globules



Liver and Gall Bladder

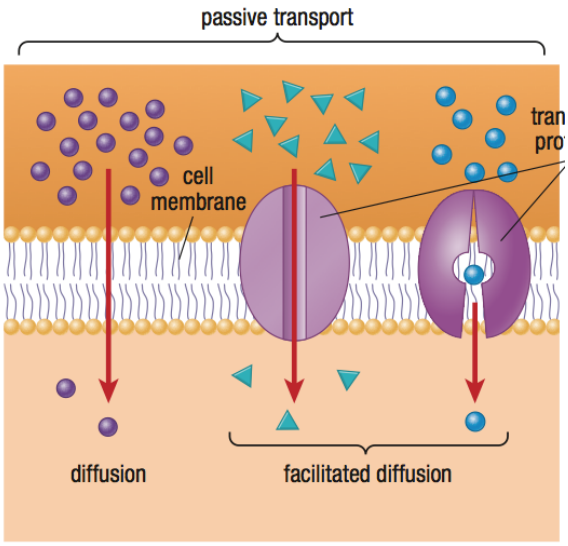
- Liver secretes bile, which is stored in the gall bladder
- Bile emulsifies fat by breaking large globules into tiny droplets of micelles
- Lipases have more surface area to act and rate of lipid digestion increases
- When lipids enter the duodenum, the gall bladder contracts and releases the bile into the duodenum

- All blood travelling through the intestine goes to the liver before returning to the heart
- Liver removes and breaks down toxins such as alcohol
- Liver produces and stores nutrients such as glycogen and fat-soluble vitamins
- Diseases of the liver:
  - Hepatitis
  - Jaundice
  - Cancer

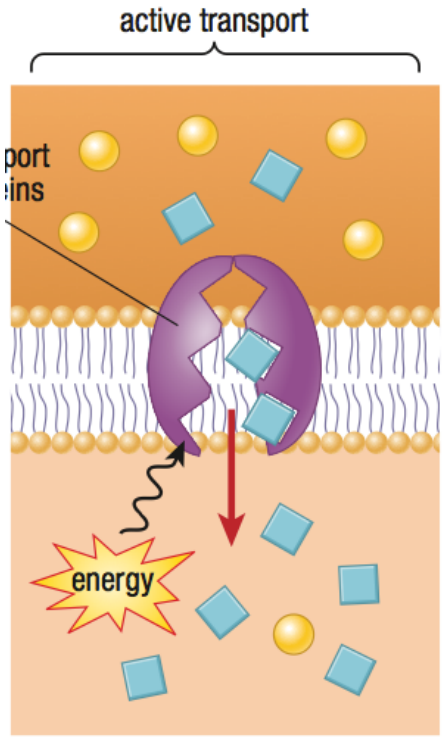
Absorption

Passive Transport

- Movement of materials across a cell membrane down a concentration gradient (from high concentration to low concentration)
- Includes:
  - Diffusion
  - Osmosis
  - Facilitated Diffusion



- Facilitated Diffusion – diffusion of molecules down a concentration gradient through transport proteins
- Transport proteins allows only certain substances to pass and control the rate of diffusion

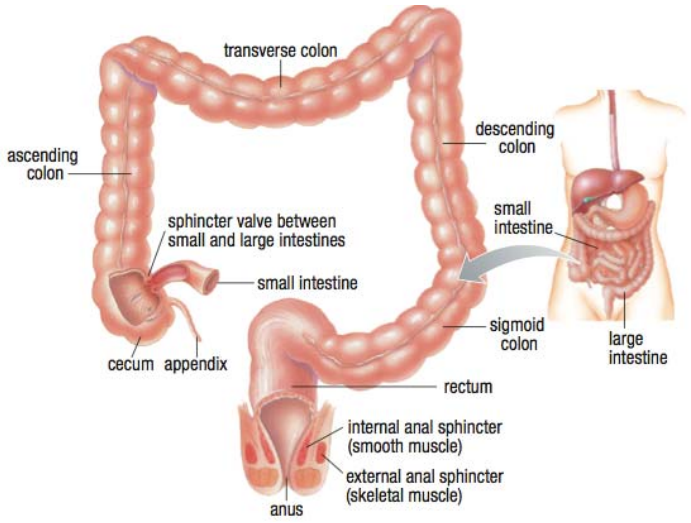


Active Transport

- Materials moved against concentration gradient (from low concentration to high concentration) using energy from ATP
- Uses transport proteins to move molecules too large to diffuse through the cell or ions that have a strong and uneven electrical charge across the membrane

Large Intestine

- Approximately 1.5m in length but larger in diameter than the small intestine
- Sections:
  - Cecum
  - Colon
  - Rectum
  - Anus



- Cecum receives processed material from the small intestine
- Colon consists of the ascending, transverse, descending and sigmoid colon
- Rectum holds the waste product of digestion until they can be eliminated
- Anus is the external opening where feces exits

- Osmosis absorbs water from the large intestine
- Vitamins B and K, sodium and chloride ions are absorbed
- Takes 4h to 72h for undigested material to pass through the large intestine
- 500 species of bacteria inhabit the large intestine and produce vitamins K and B for humans
- Bacteria can release gas (carbon dioxide, methane and hydrogen sulphide)

Egestion

- Indigestible components of food such as cellulose and other fibres maintains a full feeling for a longer time
- Fibre retains water in the large intestine to help with egestion
- Absorption of water changes the liquid material in the colon into a soft solid called feces
  - Too much water absorbed → constipation
  - Too little water absorbed → diarrhea

- Nerves in the wall of the large intestine detect the movement of feces into the rectum
- Anus is surrounded by two sphincter muscles
  - Internal anal sphincter is a smooth muscle under involuntary control
  - External anal sphincter is a skeletal muscle under voluntary control
- Feces are eliminated when both sphincters are relaxed

Endoscopy

- Endoscope is a narrow tube with a light source, lens and camera at the end
- Endoscope can be inserted through the mouth, anus or a small incision in the body cavity
- Used to collect tissue samples (biopsy), small surgical procedures such as to remove a gall bladder

Figure 10 A capsule endoscope

- Capsule endoscope can be swallowed and can pass through the entire digestive tract
- Takes pictures that are wirelessly transmitted to a receiver

Nausea and Vomiting

- Two strategies for the body to protect itself from disease-causing agents and foreign substances
- Nausea – the feelings associated with having the urge to vomit
- Emesis (Vomiting) – the expulsion of the stomach contents through the esophagus and mouth by a strong contraction of abdominal muscles

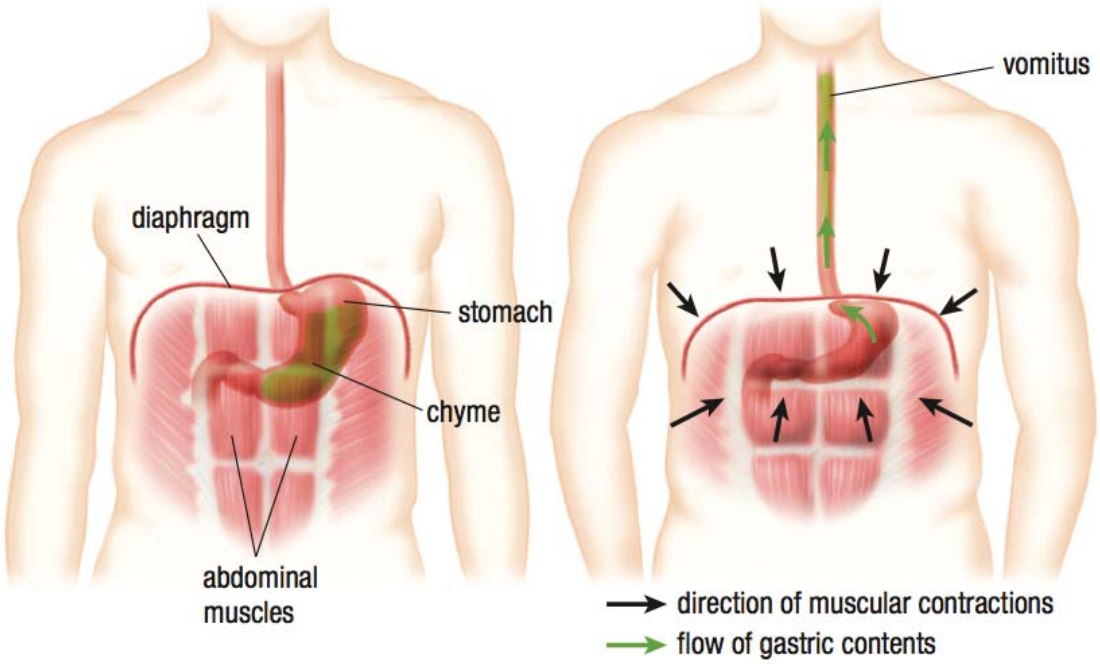


Table 1 Causes of Nausea and Vomiting

Category of conditions	Examples
inner ear	• motion sickness • Ménière's disease
drugs	• chemotherapy • alcohol
infections	• bacterial, such as food or water poisoning • viral, such as stomach flu
brain	• meningitis • tumours
injury	• concussion • hemorrhage
diseases	• cancer • ulcers

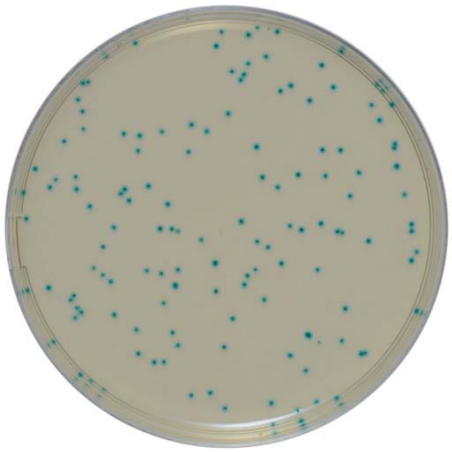
Causes of Vomiting

- Vomiting centre in the brain receives stimuli from the body
- Nausea is a symptom not a cause
- Vomiting can cause dehydration or vomitus may enter respiratory tract and cause asphyxiation or lung infection
- Vomiting can cause tears in the esophagus or strains in the abdominal muscles

Diarrhea

- Diarrhea – loose or watery feces
- Usually accompanied by other symptoms such as upset stomach, stomach pains, cramps and intestinal gas
- Causes:
  - Bacterial infection (i.e. *Salmonella, Campylobacter, E. coli*) through contaminated food or water

- *E. coli* is a serious bacterial infection that can trigger diarrhea, internal bleeding and dehydration
- Can result in kidney failure
- May 2000, Walkerton's water supply became contaminated with *E. coli* from contaminated runoff from a farm
  - 7 deaths



- *Listeria monocytogenes* is found in animal feces, plants and soil
- Contaminates food products during production, processing or preparation
- Food-borne illnesses can be reduced by proper storage, cooking of meat, poultry and seafood