The Digestive System
“Alimentary Canal”
Alimentary:

Concerning food, nourishment, and the organs of digestion.

From the Latin alimentum meaning nourishment.
## Digestion Check In

<table>
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<th>Anatomy</th>
<th>Nutrient</th>
<th>Mechanical Digestion</th>
<th>Chemical Digestion</th>
<th>Enyzmes</th>
<th>Acidic or Basic</th>
</tr>
</thead>
</table>

**Anatomy**

**Nutrient**

**Mechanical Digestion**

**Chemical Digestion**

**Enyzmes**

**Acidic or Basic**
The Digestive System

I) Introduction

- Introduction
- your digestive system is responsible for four major processes:
  - ingestion
    - taking in of food
  - digestion
    - breaking down of food, can be:
      - physical (mastication)
      - chemical
The Digestive System

I) Introduction

- ingestion
  - taking in of food
- digestion
  - breaking down of food, can be:
    - physical (mastication)
    - chemical
- absorption
  - absorbing nutrients in food and making them available to your circulatory system for transport
- elimination
  - getting rid of indigestible food.
The Digestive System
I) Introduction
The Digestive System

I) Introduction

1. Ingestion
2. Digestion
3. Absorption
4. Elimination
The Digestive System

I) Introduction

- absorption
  - absorbing nutrients in food and making them available to your circulatory system for transport

- elimination
  - getting rid of indigestible food.

- the goal of the digestive system is to ingest food, to digest into small molecules that can cross plasma membranes, to absorb nutrients and to eliminate non-digestible wastes

- in humans digestion of food is an extracellular process.
The Digestive System
II) Physiology
A schematic diagram of the human digestive system
The Digestive System
II) Physiology

A) Mouth/Oral Cavity (Bouche)

- food is chewed in the mouth (mastication) and mixed with saliva (chemical digestion)

i) Teeth

- among mammals, dentition differs according to the mode of nutrition
- humans are omnivores therefore our dentition is nonspecific to both vegetables and meat diets.
The Digestive System
II) Physiology

- Among mammals, dentition differs according to the mode of nutrition.
  - Humans are omnivores therefore our dentition is nonspecific to both vegetables and meat diets.

- Adult humans have:
  - 32 teeth
  - One-half of each jaw has teeth of four different types:
    - ~2 chisel shaped incisor for biting
    - ~1 pointed canine for tearing
    - ~2 fairly flat premolars for grinding
    - ~3 molars, well flattened for crushing
The Digestive System
II) Physiology

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The Digestive System
II) Physiology

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- herbivores like horses have:
  - sharp even incisors for clipping plant material
  - large flat premolars and molars for grinding and crushing plant material
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The Digestive System
II) Physiology

- herbivores like horses have:
  - sharp even incisors for clipping plant material
  - large flat premolars and molars for grinding and crushing plant material

- carnivores have:
  - pointed incisors and enlarged canine teeth to tear off pieces of meat that is small enough to be swallowed.
The Digestive System

II) Physiology

- Carnivores have:
  - pointed incisors and enlarged canine teeth to tear off pieces of meat that is small enough to be swallowed.
The Digestive System
II) Physiology

ii) Salivary Glands

- there are three pairs of salivary glands
  - parotid
  - sublingual
  - submandibular

- all three secrete saliva through the salivary ducts
  - lubricates the food
  - contains **salivary amylase**
The Digestive System
II) Physiology

- parotid
- sublingual
- submandibular

- all three secrete saliva through the salivary ducts
  - lubricates the food
  - contains salivary amylase
The Digestive System
II) Physiology

- submandibular
  - they secrete saliva through the salivary ducts
    - lubricates the food
    - contains salivary amylase

- this is the first site of chemical digestion
  - starch is broken down into maltose
  \[
  \text{starch} + \text{H}_2\text{O} \rightarrow \text{starch} + \text{maltose} \quad \text{(disaccharide)}
  \]
The Digestive System

II) Physiology

- iii) Tongue
  - food is manipulated by the tongue
  - tongue has:
    - pressure receptors
    - chemical receptors called taste buds.
  - the tongue pushes the chewed and saliva mixed food (the bolus) to the back of the pharynx and initiates the swallowing reflex.
II) Physiology

- pressure receptors
- chemical receptors called taste buds.

- the tongue pushes the chewed and saliva mixed food (the bolus) to the back of the pharynx and initiates the swallowing reflex.

B) Esophagus

- the esophagus conducts food
- the digestive and respiratory passages interact at pharynx.
- a small flap called the epiglottis covers the trachea.
  - the bolus passes through the pharynx entering the esophagus
  - if food enters the trachea (wind pipe) we choke.
The Digestive System

II) Physiology

- B) Esophagus
  - the esophagus conducts food
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    - a small flap called the epiglottis covers the trachea.
      - the bolus passes through the pharynx entering the esophagus
      - if food enters the trachea (wind pipe) we choke.

- when food enters the esophagus a rhythmic contraction of muscles occurs (peristalsis) pushing the bolus down the esophagus to the stomach
Food

Epiglottis up

Esophageal sphincter contracted

Esophagus

To lungs

To stomach

Tongue

Pharynx

Glottis

Larynx

Trachea

Larynx

Epiglottis

Food

To stomach

To lungs
Food

Epiglottis up

Esophageal sphincter contracted

Esophagus

To lungs

To stomach

Glottis up and closed

Epiglottis down

Esophageal sphincter relaxed

Tongue

Pharynx

Glottis

Larynx

Trachea

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Tongue
Pharynx
Glottis
Larynx
Trachea

Food
Epiglottis up
Esophageal sphincter contracted
Esophagus

To lungs
To stomach

Glottis up and closed
Esophageal sphincter relaxed

Epiglottis down
Glottis down and open

Epiglottis up
Esophageal sphincter contracted

Relaxed muscles
- Contracted muscles
- Sphincter relaxed

Stomach

http://www.hopkins-gi.org/multimedia/database/intro_250_Swallow.swf
## Digestion Check In

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<tbody>
<tr>
<td>Mouth</td>
<td>Carbohydrates</td>
<td>Yes</td>
<td>Yes</td>
<td>Salivary Amylase (polysaccharide to disaccarides)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proteins</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Acidic</td>
</tr>
<tr>
<td></td>
<td>Fats</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
The Digestive System
II) Physiology

C) Stomach

- site of:
  - food storage
  - initial protein digestion

- contains three layers of muscle that run in different directions.
  - this allows for muscle contraction to churn the food rather than just squish it.

- movement of food to and from the stomach is regulated by circular muscles called sphincters.
The Digestive System
II) Physiology

- this allows for muscle contraction to churn the food rather than just squish it.

- movement of food to and from the stomach is regulated by circular muscles called sphincters.

  sphincters act like draw strings on a bag.

  contraction of the lower esophageal sphincter (previously known as the cardiac sphincter), the LES, closes the opening to the stomach.

  the LES prevents food and acid from being regurgitated up into the esophagus.
Medical Tangent

- Acid Reflux/Heartburn
- Gastroesophageal reflux disease
  - commonly referred to as GERD or acid reflux
  - the liquid content of the stomach regurgitates (backs up or refluxes) into the esophagus.
  - can inflame and damage the lining (cause esophagitis) of the esophagus
Medical Tangent

Gastroesophageal Reflux
Medical Tangent

- the liquid content of the stomach regurgitates (backs up or refluxes) into the esophagus.
  - can inflame and damage the lining (cause esophagitis) of the esophagus

- regurgitated liquid usually contains:
  - acid and pepsin that are produced by the stomach.
  - may contain bile that has backed-up into the stomach from the duodenum.
  - Acid is believed to be the most injurious component of the refluxed liquid

- GERD is a chronic condition
  - Once it begins, it usually is life-long.
Medical Tangent

- The body has mechanisms to protect itself from the harmful effects of reflux.
  - Most reflux occurs during the day when individuals are upright.
  - In the upright position, the refluxed liquid is more likely to flow back down due to the effect of gravity.
  - While individuals are awake, they repeatedly swallow, whether or not there is reflux.
  - The salivary glands in the mouth produce saliva, which contains bicarbonate.
  - The bicarbonate neutralizes the small amount of acid.
The Digestive System

II) Physiology

- the LES prevents food and acid from being regurgitated up into the esophagus.
- the pyloric sphincter regulates the movement of food and stomach acids into the small intestine.
The Digestive System
II) Physiology

- the L-shaped stomach has numerous ridges called rugae
  - allow for expansion
- millions of cells line the inner wall of the stomach.
  - these cells secrete gastric fluids or juices that aid digestion.
  - the main components of gastric juice are:
    - mucus
    - hydrochloric acid
    - pepsinogens
The Digestive System
II) Physiology

- the main components of gastric juice are:
  - mucus
  - hydrochloric acid
  - pepsinogens

- parietal cells of the stomach
  - secretes hydrochloric acid (HCl\(_{aq}\))
    - lowers the pH of the stomach to around 2
      - kills many harmful substances that are ingested with food.
      - deactivates salivary amylase
    - converts pepsinogen into its active form pepsin.
The Digestive System
II) Physiology

- kills many harmful substances that are indigested with food.
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**peptic/Chief cells of the stomach**
- secretes pepsinogen
- pepsinogen is an inactive enzyme.
- it stays inactive until it reaches the lumen of the stomach and is activated by \( \text{HCl}_{(aq)} \) (it is now called pepsin)
The Digestive System
II) Physiology

- peptic/ Chief cells of the stomach
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  - pepsinogen is an inactive enzyme.
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\[
\begin{align*}
\text{Pepsinogen} & \quad \xrightarrow{\text{HCl}} \quad \text{Pepsin} \\
\text{Pepsin} & \quad \xrightarrow{} \quad \text{Shorter Chain Amino Acids (Peptones)} \quad \text{Long Chain Amino Acids (Proteins)}
\end{align*}
\]
mucus cells of the stomach
- secretes mucus
  - mucus provides a protective coating to prevent self digestion of the stomach lining

another chemical secreted by the cells of the stomach is renin.
- renin works to slow down the movement of milk through the digestive system
Pepsinogen and HCl are secreted.

HCl converts pepsinogen to pepsin.

Pepsin activates more pepsinogen.
The Digestive System
II) Physiology

- another chemical secreted by the cells of the stomach is renin.
  - renin works to slow down the movement of milk through the digestive system

- after the action of gastric juice (chemical digestion) and stomach contractions (physical digestion) the contents of the stomach have a thick, soupy consistency.
  - this is called chyme.

- the base of the stomach has a sphincter called the pyloric sphincter.
Medical Tangent

- Peptic Ulcer
- when the protective mucus lining of the stomach breaks down the cell membrane is exposed to HCl and pepsin
  - the breakdown of the cell membrane of the stomach is a peptic ulcer.
- must ulcers are the result of an infection by the bacterium *Helicobacter pylori*.
- peptic ulcers can be treated with antibiotics if found early enough
The Digestive System
II) Physiology

- The base of the stomach has a sphincter called the pyloric sphincter.
  - When the sphincter relaxes a small amount of chyme passes into the duodenum (the first part of the small intestine).
  - Chyme entering the duodenum sets off a reflex that causes the sphincter to contract and close the opening temporarily.
  - This adaptation allows for a slower more thorough digestion.
Gall-bladder
Small intestine
Large intestine
Pancreas
Liver
Stomach
Sphincter
Duodenum of small intestine
Gall-bladder
Small intestine
Stomach
Gall-bladder
Liver
Pancreas
Small intestine
Stomach
Small intestine
The Digestive System
II) Physiology

D) Small Intestine
- site of majority of digestion and absorption
- is approximately 7 metres in length
- it is called the small intestine because it is narrower than the large intestine.
- is made up of three regions
  - duodenum
  - jejunum
  - ileum
- the mucus membrane layer of the small intestine has ridges and furrows that give it corrugated appearance.
The Digestive System
II) Physiology

- the mucus membrane layer of the small intestine has ridges and furrows that give it corrugated appearance.
  - on the surface of these ridges and furrows are small fingerlike projections called villi.
    - cells on the surface of the villi have minute projections called microvilli.
  - the villi and microvilli greatly increase the effective surface area of the small intestine.
  - if the small intestine was a smooth tube, it would have to be 500 to 600 meters long to have a comparable surface area.
Fig. 41-15a

Muscle layers

Vein carrying blood to hepatic portal vein

Villi

Intestinal wall

Key

Nutrient absorption

Large circular folds
Fig. 41-15b

Microvilli (brush border) at apical (lumenal) surface

Key

Nutrient absorption
The Digestive System

II) Physiology

- the villi and microvilli greatly increase the effective surface area of the small intestine.
- if the small intestine was a smooth tube, it would have to be 500 to 600 meters long to have a comparable surface area.

- when chyme enters the duodenum:
  - proteins and carbohydrates are partly digested
  - fat digestion still needs to be carried out.

- more digestion is still required before nutrients can be absorbed through the intestinal wall.
  - two accessory glands, the liver and the pancreas send secretions to the duodenum to complete digestion.
The Digestive System
II) Physiology

- More digestion is still required before nutrients can be absorbed through the intestinal wall.

  - Two accessory glands, the liver and the pancreas send secretions to the duodenum to complete digestion.
    
    i) Liver
    
    ii) Pancreas
The Digestive System
II) Physiology

i) liver

- the liver produces bile
- bile is
  - stored in the gall bladder
  - is sent to the duodenum via the bile duct
  - contains bile salts which are emulsifying agents
    (Emulsifying agents break up fat into fat droplets so they can mix with water)
The Digestive System

II) Physiology

- contains bile salts which are emulsifying agents
- (Emulsifying agents break up fat into fat droplets so they can mix with water)

\[
\text{fat} \cdot \text{bile salts} \cdot \text{fat droplets}
\]

- emulsified fats are more easily digested by enzymes (more surface area)
The Digestive System
II) Physiology

- **Fat** - *bile salts* - *fat droplets*

- Emulsified fats are more easily digested by enzymes (more surface area)

- When the stomach is empty, bile is stored and concentrated in the gall bladder.

- When there is fat in the small intestine, the hormone cholecystokinin (CCK) is released.

- CCK is carried in the bloodstream to the gall bladder.

- Triggers the release of bile salts
The Digestive System
II) Physiology

- CCK is carried in the blood stream to the gall bladder.
  - triggers the release of bile salts
  - once inside the duodenum the bile salts emulsify fat into fat droplets
  - (this is physical digestion because chemical bonds are not broken)
Secretin and CCK

Stomach

Gallbladder

Liver

Duodenum of small intestine

Bile

Pancreas

Gastrin

Key

+ Stimulation

- Inhibition
The Digestive System
II) Physiology

- Once inside the duodenum, the bile salts emulsify fat into fat droplets.
- (This is physical digestion because chemical bonds are not broken.)

- Bile also contains pigments:
  - The liver breaks down hemoglobin (Hb) from red blood cells (RBC) and stores the products in the gall bladder for removal.
  - The characteristics brown color of feces results from Hb breakdown.
The Digestive System
II) Physiology

- the characteristics brown colour of feces results from Hb breakdown

- other liver functions:
  - synthesis
  - produces bile salts
  - manufactures blood proteins
  - breakdown/conversion
  - removes toxic nitrogen group from amino acids forming urea
  - converts the toxic components of hemoglobin (excreted by bile salts)
The Digestive System
II) Physiology

- **breakdown/conversion**
- removes toxic nitrogen group from amino acids forming urea
- converts the toxic components of hemoglobin (excreted by bile salts)
- converts glucose into glycogen and vice versa to maintain a constant blood sugar level.

- **storage**
- stores glycogen
- stores vitamins A, B12 and D
- **detoxification**
- converts harmful compounds (ie. alcohol) to less harmful products.
The Digestive System
II) Physiology

- detoxification
  - converts harmful compounds (i.e. alcohol) to less harmful products.

- ii) Pancreas

- when acid enters the small intestine, a chemical called prosecretin is converted into secretin
  - secretin is absorbed into the bloodstream and carried to the pancreas
    - it signals the pancreas to release a solution containing bicarbonate ions ($\text{HCO}_3^-$)
    - bicarbonate travels through the pancreatic duct to the small intestine.
    - in the small intestine bicarbonate raises the pH from about 2.5 (acidic) to 9.0 (basic)
The Digestive System
II) Physiology

- in the small intestine bicarbonate raises the pH from about 2.5 (acidic) to 9.0 (basic)
- the basic pH inactivates pepsin.
  - the small intestine is protected from the stomach acids and protein digesting enzymes.
- pancreatic secretions contain enzymes that digest all three major nutrients:
  - proteins
  - carbohydrates
  - lipids
The Digestive System
II) Physiology

- Pancreatic secretions contain enzymes that digest all three major nutrients:
  - ~ proteins
  - ~ carbohydrates
  - ~ lipids

- Pancreatic secretions or “juice” contains:
  - sodium bicarbonate (for neutralization)
  - pancreatic amylase
  - trypsinogen/trypsin
  - lipase
  - erepsin
The Digestive System
II) Physiology

- pancreatic secretions or “juice” contains:
  - sodium bicarbonate (for neutralization)
  - pancreatic amylase
  - trypsinogen/trypsin
  - lipase
  - erepsin

- pancreatic amylase
  - digest any remaining starches to maltose
  - (polysaccharides $\Rightarrow$ disaccharides)
The Digestive System
II) Physiology

- pancreatic amylase
  - digest any remaining starches to maltose
  - (polysaccharides ⇔ disaccharides)

- trypsinogen
  - an inactive enzyme
  - is activated by another enzyme called enterokinase in the lumen of the duodenum
The Digestive System
II) Physiology

- trypsinogen
  - an inactive enzyme
  - is activated by another enzyme called enterokinase in the lumen of the duodenum

\[
\text{trypsinogen (inactive)} \\
\quad \text{enterokinase} \\
\text{trypsin (active)}
\]

proteins & peptones  smaller amino chains (peptides)
  - erepsins
    - amino acids
The Digestive System

II) Physiology

- tyrosinogen
  - an inactive enzyme
  - is activated by another enzyme called enterokinase in the lumen of the duodenum

- erepsins
  - complete protein digestion by breaking the bonds between short-chain peptides, releasing amino acids.
  - released from the pancreas and the small intestine

- lipase
  - enzymes released by the pancreas
  - break down lipids
  - two types
The Digestive System
II) Physiology

- lipase
  - enzymes released by the pancreas
  - break down lipids
  - two types
    - pancreatic lipase
      - ~ most common
      - ~ breaks down fats into fatty acids and glycerol
    - phospholipase
      - ~ breaks down phospholipids
The Digestive System
II) Physiology

- pancreatic lipase
  - ~ most common
  - ~ breaks down fats into fatty acids and glycerol
- phospholipase
  - ~ breaks down phospholipids

- back to the small intestine

At this point:
- fats are fully digested
- carbohydrates are partially digested
- proteins are fully and partially digested.

- epithelial cells of the villi produce intestinal enzymes (intestinal juice)
- this completes the digestion of peptides and sugars
The Digestive System
II) Physiology

- fats are fully digested
- carbohydrates are partially digested
- proteins are fully and partially digested.
- epithelial cells of the villi produce intestinal enzymes (intestinal juice)
- this completes the digestion of peptides and sugars

peptides → peptidase → amino acids

disaccharides : maltase → monosaccharides
 lactase
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<tr>
<td>Small Intestine</td>
<td>Lipids</td>
<td></td>
<td></td>
<td><strong>Lipase</strong></td>
<td>Basic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Lipids → fatty acids + glycerol)</td>
<td>(pH = 8)</td>
</tr>
<tr>
<td></td>
<td>Proteins</td>
<td></td>
<td></td>
<td><strong>Proteases</strong></td>
<td></td>
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<td></td>
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<td></td>
<td><strong>Trypsin</strong></td>
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<td>(Peptides → smaller peptides)</td>
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<td><strong>Chymotrypsin</strong></td>
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<td></td>
<td></td>
<td></td>
<td>(Peptides → smaller peptides)</td>
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<td><strong>Peptidases</strong></td>
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<td></td>
<td></td>
<td></td>
<td>(peptides → smaller peptides and amino acids)</td>
<td></td>
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<tr>
<td></td>
<td>Carbohydrates</td>
<td></td>
<td>X</td>
<td><strong>Pancreatic Amylase</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(glycogen, starch → maltose)</td>
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<td></td>
<td><strong>Carbohydrases</strong></td>
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<td></td>
<td></td>
<td></td>
<td>sucrase (sucrose → glucose + fructose)</td>
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<td></td>
<td>maltase (maltose → glucose)</td>
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<td></td>
<td></td>
<td>lactase (lactose → glucose + galactose)</td>
<td></td>
</tr>
</tbody>
</table>
The Digestive System
II) Physiology

- absorption of nutrients
  - each villus contains a network of blood vessels and a small lymphatic vessel called a lacteal
  - after glycerol and fatty acids are absorbed by epithelial cells, they are recombined into fats within these cells
  - these fats are mixed with cholesterol and coated with protein, forming molecules called chylomicrons, which are transported into lacteals
Lumen of small intestine

- Triglycerides
  - Fatty acids
  - Monoglycerides
  - Epithelial cell
  - Triglycerides
  - Phospholipids, cholesterol, and proteins
  - Chylomicron

Lacteal
II) Physiology

- These fats are mixed with cholesterol and coated with protein, forming molecules called **chylomicrons**, which are transported into lacteals.

- Amino acids and sugars pass through the epithelium of the small intestine and enter the bloodstream.

- Capillaries and veins from the lacteals converge in the **hepatic portal vein** and deliver blood to the liver and then on to the heart.
Bloodstream

Veins to heart

Lymphatic system

Hepatic portal vein

Liver

Bloodstream

Absorbed food (except lipids)

Absorbed water

Mouth

Esophagus

Stomach

Secretions from the gastric glands of the stomach

Secretions from the pancreas and the liver

Lipids

Small intestine

Large intestine

Rectum

Anus

Absorbed food (except lipids)

Absorbed water

Lipids

Mouth

Esophagus

Stomach

Secretions from the gastric glands of the stomach

Secretions from the pancreas and the liver

Lipids

Small intestine

Large intestine

Rectum

Anus
The Digestive System
II) Physiology

- E) Large Intestine
  - chemical digestion is complete
  - the cecum
    - the first area where food from the small intestine arrives.
    - has a small blind pouch attached to it called the appendix.
  - the colon:
    - the largest part of the large intestine.
    - stores wastes long enough to reabsorb water
    - inorganic salts, minerals and vitamins are reabsorbed with the water.
  - home to *Escherichia coli* (*E. coli*) bacteria
The Digestive System
II) Physiology

- Inorganic salts, minerals and vitamins are reabsorbed with the water.
- Home to *Escherichia coli* (*E. coli*) bacteria
- Uses waste materials to synthesize vitamins B and K.
- As wastes build up receptors in the cell wall send a signal to the central nervous system promoting a bowel movement.
- Bowel movements ensure removal of potentially toxic wastes from the body.
- People who do not eat enough fibre (cellulose) have fewer bowel movements.
bowel movements ensure removal of potentially toxic wastes from the body.

people who do not eat enough fibre (cellulose) have fewer bowel movements.

- wastes of the digestive tract, the **feces**, become more solid as they move through the colon
- feces pass through the rectum and exits via the anus
- feces is stored in the **rectum** until they can be eliminated
- two sphincters between the rectum and anus control bowel movements
The Digestive System
II) Physiology

- interesting adaption
  - herbivores generally have longer alimentary canals than carnivores, reflecting the longer time needed to digest vegetation
<table>
<thead>
<tr>
<th>Carbohydrate digestion</th>
<th>Protein digestion</th>
<th>Nucleic acid digestion</th>
<th>Fat digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Polysaccharides</strong></td>
<td><strong>Protein digestion</strong></td>
<td><strong>Nucleic acid digestion</strong></td>
<td><strong>Fat digestion</strong></td>
</tr>
<tr>
<td>(starch, glycogen)</td>
<td>Proteins</td>
<td>DNA, RNA</td>
<td>Fat globules</td>
</tr>
<tr>
<td><strong>Disaccharides</strong></td>
<td>Small polypeptides</td>
<td>Nucleotides</td>
<td>Fat droplets</td>
</tr>
<tr>
<td>(sucrose, lactose)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smaller polysaccharides, maltose</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maltose and other disaccharides</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Polysaccharides</strong></td>
<td>Polypeptides</td>
<td>DNA, RNA</td>
<td>Fat globules</td>
</tr>
<tr>
<td><strong>Monosaccharides</strong></td>
<td>Small peptides</td>
<td>Nucleotides</td>
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</tr>
<tr>
<td></td>
<td>Amino acids</td>
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<td></td>
</tr>
</tbody>
</table>

- Carbohydrates: Starch, glycogen, sucrase, lactose
- Disaccharides: Maltose other disaccharides
- Monosaccharides: Amino acids
- Proteins: Small polypeptides
- Polypeptides: Smaller polypeptides
- DNA, RNA: Nucleotides
- Fat: Globules, fatty acids, monoglycerides
Oral cavity, pharynx, esophagus

- Polysaccharides (starch, glycogen)
  - Disaccharides (sucrose, lactose)
  - Salivary amylase
  - Smaller polysaccharides, maltose

Stomach

- Proteins
  - Pepsin
  - Small polypeptides

Lumen of small intestine

- Polysaccharides
  - Pancreatic amylases
  - Maltose and other disaccharides

- Disaccharides
  - Pancreatic trypsin and chymotrypsin
  - Smaller polypeptides
  - Pancreatic carboxypeptidase
  - Amino acids

Epithelium of small intestine (brush border)

- Monosaccharides
- Disaccharidases
- Dipeptidases, carboxypeptidase, and aminopeptidase
- Amino acids

Protein digestion

- Proteins
- Small polypeptides
- Pepsin
- Small polypeptides
- Pancreatic carboxypeptidase
- Amino acids

Nucleic acid digestion

- DNA, RNA
- Pancreatic nucleases
- Nucleotides

Fat digestion

- Fat globules
- Bile salts
- Pancreatic lipase
- Glycerol, fatty acids, monoglycerides
- Nucleotidases
- Nucleosidases and phosphatases
- Nitrogenous bases, sugars, phosphates
The Digestive System

III) Control of Digestion

- Control of digestion is exerted by the nervous and endocrine (hormonal system)
  - Seeing, smelling and tasting food will produce gastric secretions before there is any food in the stomach.
  - Swallowing stimulates gastric secretions even if the esophagus is empty.
- Hormones play a large role in control
- hormones play a large role in control
  - secretin
    - is released when acid from the stomach moves into the small intestine.
    - travels to the pancreas via the blood stream where it stimulates the release of bicarbonate to raise the pH.
  - gastrin
    - produced when the wall of the stomach are distended by the presence of food and by the presence of partially digested protein.
    - travels in the blood and stimulates the parietal cells of the stomach to release HCl.
- gastrin
  - produced when the wall of the stomach are distended by the presence of food and by the presence of partially digested protein.
  - travels in the blood and stimulates the parietal cells of the stomach to release HCl.

- the size of the meal
  - a larger meal will trigger more receptors in your stomach causing more forcefull contractions and faster emptying.
  - a fatty meal will cause the small intestine to secrete enterogastrone which will slow peristaltic movement allowing more time for fat digestion and absorption.