Protein Digestion and Absorption

Digestion

- Process that breaks down food into molecules small enough to absorb.
- Break polymers into monomers that are easier to absorb and that can be used to synthesize new polymers required by the organism.

Absorption

- Cells that line tract take up nutrients
- Nutrients move to cells where they are
- Incorporated into the cells
- Converted to energy which may be used immediately or stored until needed

In Mouth

- No significant digestion of proteins takes place in the mouth except for the tearing apart of connective tissue (which is mostly proteins like collagen).
- Stimulated by the smell, sight and taste or thought of food, saliva is released.

In Mouth

- Saliva contains: mucin (a glycoprotein lubricant), amylase (to break down the complex carbohydrates starch and glycogen)

In Stomach

- Stimulated by food on the way down, the neurotransmitters acetylcholine and histamine are released onto the cells of the stomach
- Stimulated by food in the stomach, the hormone gastrin is released.

In Stomach

- The combination of acetylcholine, histamine and gastrin cause the release of the gastric juices.
  - mucin - is always secreted in the stomach
  - HCl - pH 0.8-2.5 (secreted by parietal cells)
  - pepsinogen (a zymogen, secreted by the chief cells)
  - gastric lipase (an enzyme that acts on fats, but is active in the intestines)

In Stomach

- Proteins are denatured by the low pH
- Low pH acts as an antiseptic and kills most bacterias and other foreign cells.

Digestion in the Stomach

- The zymogen Pepsinogen (MW=40,000) released in the stomach is activated by the enzyme pepsin already in the stomach and the stomach acid. Pepsinogen has 42 amino acids cleaved off to become the enzyme pepsin (MW=33,000) and a peptide fragment to be degraded.

Digestion in the Stomach

- Pepsin will partially digest proteins by cleaving the peptide bond on the N-side of the aromatic amino acids: Phe, Tyr, Trp

Digestion in the Duodenum

- As the acidic stomach contents called Chyme enter the duodenum, the low pH triggers the release of the hormone secretin into the blood. The amino acids stimulate the release of cholecystokinin.
- The secretin stimulates the pancreas to secrete bicarbonate into the small intestine. (pH changes to about 7)

Digestion in the Duodenum

- The cholecystokinin stimulates the pancreas exocrine cells to secrete trypsinogen, chymotrypsinogen and procarboxypeptidase into the intestine. (The exocrine cells also contain the protein trypsin inhibitor to protect themselves from free trypsin.)

Digestion in the Duodenum

- The intestinal cells secrete an enzyme called enteropeptidase that acts on trypsinogen cleaving it into trypsin.
- Trypsin converts chymotrypsinogen into chymotrypsin, procarboxypeptidase into carboxypeptidase and proelastase into elastase (I don't know where the proelastase comes from), and trypsinogen into more trypsin.

Digestion in the Duodenum

- Trypsin which cleaves peptides on the carboxyl side of the basic amino acids Lys and Arg.
- Chymotrypsin which cleaves on the carboxyl side of the aromatic amino acids Phe, Tyr and Trp.
  - A zinc requiring enzyme.

Digestion in the Duodenum

- Carboxypeptidase which cleaves all amino acids on the remaining fragments one amino acid at a time from the carboxyl side. (This would be cutting the N-side of the C-terminal amino acid.)
- Elastase which breaks apart the derived amino acid desmosine.

Digestion in the Duodenum

- Aminopeptidase is secreted from the cells of the small intestine and they cleave off the N-terminal amino acids one at a time from all peptides.
- Most proteins are completely digested to free amino acids, absorbed and then transported in the blood to the cells of the body.

Digestion in the Duodenum

- Keratin and other fibrous proteins are poorly digested and pass on through.
- Many plant proteins are encased in cellulose and thus escape digestion.

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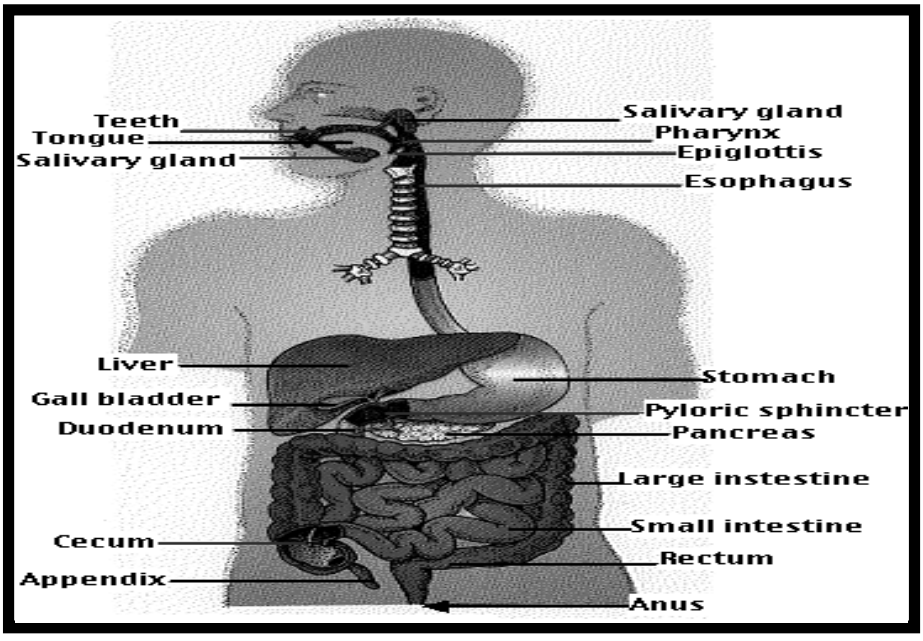

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Component of Gastrointestinal System

- Mouth
- Oral cavity
- Tongue
- Pharynx
- Salivary Glands
- Esophagus
- Stomach
- Liver
- Gall Bladder
- Pancreas
- Small Intestine
- Large Intestine
- Rectum
- Anus

Oral Cavity

- Food enters the mouth and is reduced in size by teeth and tongue.
- Salivary glands secrete saliva which
  - Lubricates
  - Buffers
  - Contains antimicrobial substances
  - Contains amylase to digest starch

Swallowing

- Food passes to pharynx which contains both trachea and esophagus
- Epiglottis prevents food from entering trachea
- Food passes through esophagus into the stomach

Stomach

- Stores and digests food
- Contains pits leading to Gastric glands with three types of cells:
- Mucous cells - produce mucous which lubricates and protects lining.
- Parietal cells - secrete hydrochloric acid
- Chief cells - secrete pepsinogen

Small Intestine

- Receives food from stomach
- Bile from liver via the Gall bladder
- Enzymes from pancreas
- Site of most digestion
- Site of most absorption

Duodenum

- First 25 cm of small intestine
- Receives enzymes from pancreas
- Neutralizes acid from stomach
- Site of most chemical changes in food

Enzymes

- Fat + bile and lipase = Fatty acids + glycerol
- Starch + Amylase = simple sugars
- Maltose + maltase = glucose + glucose
- Sucrose + sucrase = glucose + fructose
- Lactose + lactase = glucose + galactose
- Protein + protease = amino acids

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Pancreas

- Releases critical enzymes for digestion
- Neutralize acid by releasing bicarbonate
- Insufficient pancreatic function can lead to starvation

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Liver

- Produces bile
- No digestive enzymes, but contains bile salts
- Emulsifies fats
- Made from cholesterol
- Stored in Gall Bladder

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Enzymatic Action - Carbohydrates

- Starch broken down into the disaccharide , maltose, by pancreatic amylases.
- Disaccharides converted to monosaccharides
  - Maltose is hydrolyzed by Maltase to give Glucose + Glucose
  - Sucrose is hydrolyzed by Sucrase to give Glucose + Fructose
  - Lactose is hydrolyzed by Lactase to give Glucose + Galactose

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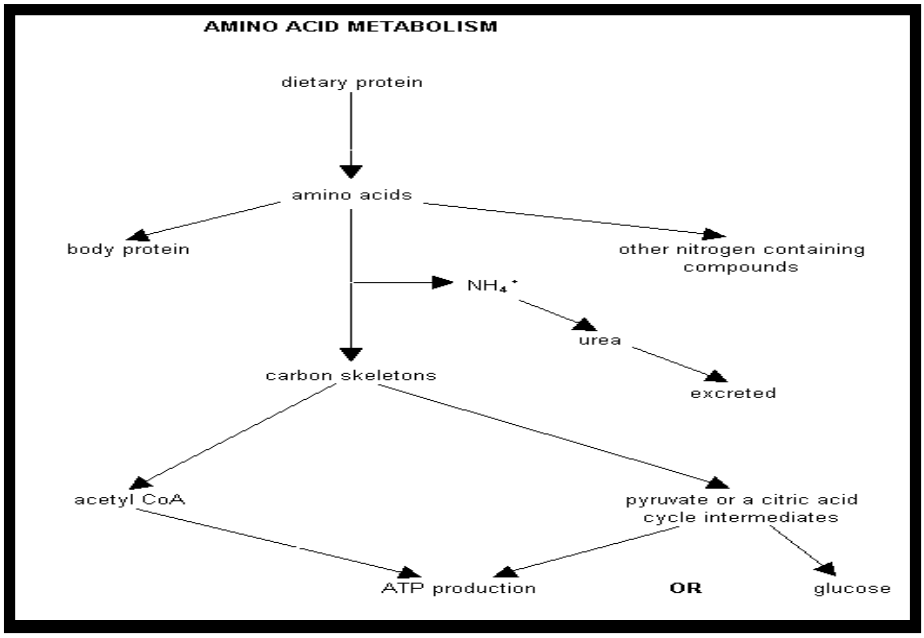
Absorption

- Following enzymatic action in the duodenum, food is absorbed in the remainder of the small intestine
- Has a very large surface area
- Contains Villi and microvilli
- Rich in capillaries and lymph vessels

Large Intestine

- Material not be digested or absorbed passes into the large intestine.
- 90% of the water is absorbed into blood
- Some vitamins are produced by bacteria and are absorbed
- Residue is stored in rectum
- Eliminated through the anus



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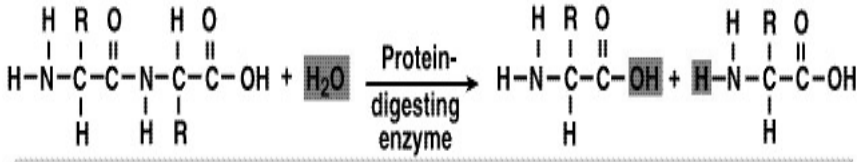
How are proteins absorbed?

Protein



Peptide (portion of protein molecule) + Water → Amino acid + Amino acid

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How are proteins absorbed?

- The absorptive cells of the small intestine can only absorb individual amino acids, dipeptides or tripeptides.
- Once transported inside the cells all di/tripeptides are broken down into individual amino acids by proteases within the cells.
- Like monosaccharides, the amino acids are transported out of the absorptive cells and diffuse into the capillaries to move into general circulation.

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