**Protein Metabolism**

Proteins, the primary constituents of the body, may be structural or functional. A regular and adequate supply of protein in the diet is essential for cell integrity and function. Dietary proteins are the primary sources of nitrogen that are metabolized by the body. Adult man requires 70 to 100 gm proteins per day. Dietary proteins serve three broad functions:

* Their constituent amino acids are used for synthesis 0f the body’s proteins.
* The carbon skeletons of the amino acids can be oxidized to yield energy and
* Their carbon and nitrogen atoms may be used to synthesize other nitrogen-containing cellular constituents as well as many non-nitrogen containing metabolites.

**Digestion and Absorption of Proteins**

Proteins are too large to be absorbed by the intestine. Therefore they must be hydrolyzed to yield constituent amino acids, which can be absorbed. Proteolytic enzymes (also called proteases) break down dietary proteins into their constituent amino acids. These enzymes are produced by three different organs; the stomach, the pancreas and the small intestine.

**DIGESTION OF PROTEINS**

1. **Digestion in mouth**

There is no digestion of protein in the mouth. It starts in the stomach.

1. **Digestion in stomach**

When protein enters the stomach, it stimulates the secretion of the hormone gastrin,from gastric mucosal cells, which, in turn, stimulates the release of gastric juice containing: hydrochloric acid,

proenzyme(zymogen) pepsinogen and rennin in infants. The gastric juice has pH between 1.5 and 2.5.

1. **Hydrochloric Acid**

It is secreted by partial cells that kill microorganisms. Denatures proteins making their internal peptide bonds more accessible to subsequent hydrolysis by proteoses. It also provides an acid environment for the action of pepsin.

1. **Pepsin**

It is secreted by chief cells as the proenzymes pepsinogen, an inactive precursor. It is converted into active pepsin in the gastric juice by the enzymatic action of pepsin itself, called autocatalysis or by high hydrogen ion concentration, autoactivation. Pepsin works at acidic pH. Although pepsin has a broad specificity, it cleaves those peptide bonds of protein involving the;

-**aromatic amino acids** (phenylalanine, tyrosine and tryptophan) or

-**acidic amino acids (**aspartic acid and glutamic acid**).**

Thus pepsin cleaves long polypeptide chains into a mixture of smaller peptides and some free amino acids

1. **Renin**

Renin is important in the digestive processes of infants. It is absent in adults. Renin is also called chymosin or rennet. The action of renin is to clot milk. This is accomplished by slight hydrolysis of the casein of milk to produce paracasein, which coagulates in the presence of calcium ions, resulting in an insoluble calcium-paracaseinate curd. Calcium paracaseinate is then acted on by pepsin

Ca++

Rennin

**Casein paracasein Ca-paracaseinate**

The purpose of this reaction is to convert milk into a more solid form to prevent the rapid passage of milk from the stomach of infants.

**Assignment 01:** What are the differences between rennin and renin?

**(c ) Digestion in the intestine by pancreatic enzymes**

As the acidic stomach contents (chyme) pass into the small intestine, the low pHtriggers the secretion of the hormones, cholecystokinin and secretin. Secretin stimulates the pancreas tosecrete bicarbonate and release of pancreatic juice into the small intestine. It neutralizes the gastric HCl. The pHthen rises abruptly from 1.5 and 2.5 to about pH 7.00. Cholecystokinin and stimulates the secretion of pancreatic endopeptidase and exopeptidase enzymes, whose optimum pHs are near 7.00.

1. **Endopeptidase**

Endopeptidases cleave internal peptide bonds. This results into formation of smaller peptides from large polypeptides. Endopeptidases, secreted by the pancreas, are trypsin, chymotrypsin and elastase, which are secreted in proenzymes (inactive) forms, trypsinogen, chymotrypsinogen and proelastase.

1. **Exopeptidase**

Exopeptidases cleave off one amino acid at a time from either the C or N terminal of the polypeptide, e.g. carboxypeptidase and aminopeptidase

Exopeptidase secreted by the pancreas is carboxypeptidase, secreted in proenzyme form, procarboxy-peptidase. Aminopeptidase secreted by the mucosal cell.

1. **Activation of Pancreatic Proenzymes**

Activation of the pancreatic proenzymes occurs by the action of enteropeptidase (enterokinase),secreted by duodenal epithelial cells. Enteropeptidase activates trypsinogen to trypsin and the activated trypsin, in turn, activates more trypsinogen. Trypsin also activates the proenzyme of the chymotrypsin, elastase and carboxypeptidase.

1. **Trypsin**

Trypsin attacks certain proteins that cannot be digested by pepsin. **T**rypsin hydrolyzes those peptide bonds whose carboxyl groups are contributed by lysine and arginine residues. Several proteins like substances, that block the action of trypsin and related enzymes, are called trypsin inhibitors

1. **Chymotrypsin**

Chymotrypsin preferentially cleaves bonds involving the carboxyl group of aromatic amino acids. It also splits peptide linkages of leucine, methionine, asparagine, and histidine.

1. **Elastase**

Elastase hydrolyses those peptide bonds, formed by small non-polar amino acid residues, such as alanine, serine, and glycine. Trypsin, chymotrypsin, and elastase, thus, hydrolyse polypeptides, resulting from the action of pepsin in thestomach into smaller peptides.

1. **Carboxypeptidase**

Degradation of short peptides in the small intestine is continued by an exopeptidase, carboxypeptidase (zinc-containing enzyme), which removes the successive carboxyl-terminal amino acid residues from the peptide.

-**Carboxypeptidase-A** preferentially releases hydrophobic amino acids and **Carboxypeptidase-B** releases basic amino acids.

1. **Digestion in intestine by intestinal proteoses**

The digestion products of hydrolysis by pepsin, trypsin, elastase, chymotrypsin and carboxypeptidase is completed by peptidases, secreted by the mucosa of the small intestine. A number of peptidases are present in the intestinal mucosal cells, such as:

1. **Aminopeptidase**

It is an exopeptidase, hydrolyze peptide bonds next to N-terminal amino acids of the short peptides. Aminopeptidases require magnesium or manganeseions for their activity.

1. **Dipeptidases**

There are several dipeptidases, that are specific for dipeptides. The dipeptidases complete the digestion of dipeptides to free amino acids. These dipeptidases can then finally convert all ingested protein into free amino acids. Dipeptidases require cobalt or manganeseions for their activity. Dipeptidase and tripeptides are usually absorbed as such and are digested to free amino acids within the intestinal mucosal cells.

 The hydrolysis of most proteins is thus completed to their constituent amino acids which are then ready for absorption into the blood plasma. A few proteins, e.g. silk and several other albuminoids are resistant to digestion.

**ABSORPTION OF AMINO ACIDS**

 **T**he absorption of most amino acids involves an active transport mechanism,requiring ATP and specific transport proteins in the intestinal mucosal cells. Many transporters have Na+ dependent mechanisms, coupled with Na+K+ pump. Several transport proteins are found In the Brush border membranes that are not specific for each amino acid but rather for the groups of structurally similar amino acids.

Five separate systems have been identified for the transport of amino acids from the intestinal lumen into the intestinal epithelial cell. All are specific for only L-amino acid (stereospecific transporter). D-amino acids are transported by passive diffusion. Thus amino acids, released by digestion, pass from the gut through the hepatic portal vein to the liver. These transporter systems are also present in the renal tubules where they reabsorb amino acids from the glomerular filtrate before excretion of urine. Defects in their transporter proteins can lead to disease.

**Assignment 02:** Write briefly on the absorption of intact protein