Secretion	Source	Function
Bile – contains no enzymes	Made in liver, stored in gall bladder, released into duodenum	Neutralises gut contents, emulsifies fats
Amylase	Made in pancreas, released into duodenum. Also made in crypts of Lieberkuhn and associated with brush border of villi in ileum	Breaks down *starch* to *maltose*
Trypsin - secreted as trypsinogen	Trypsinogen is made in the pancreas and secreted into the duodenum. Activated by enterokinase	Breaks down *proteins* to *polypeptides*
Lipase	Made in the pancreas and secreted into the duodenum	Breaks down *fats* to *fatty acids* and *glycerol*
Endopeptidase, e.g. chymotrypsin, trypsin	Made in the pancreas and secreted into the duodenum	Break down *proteins* to *polypeptides* and *polypeptides* to short *peptides*
Exopeptidases, e.g. aminopeptidase, carboxypeptidase	Made in the pancreas and secreted into the duodenum	Break down *peptides* to *amino acids*
Nuclease	Made in the pancreas and secreted into the duodenum	Breaks down *nucleic acids* (DNA, RNA) into *nucleotides*
Enterokinase	Secreted by the lining of the small intestine	Converts inactive *trypsinogen* to active *trypsin*
Maltase	Secreted by the lining of the small intestine	Breaks down *maltose* to *glucose*
Sucrase	Secreted by the lining of the small intestine	Breaks down *sucrose* to *glucose* and *fructose*
Lactase	Secreted by the lining of the small intestine	Breaks down *lactose* (milk sugar) to *glucose* and *galactose*
Nucleotidases	Secreted by the lining of the small intestine	Breaks down *nucleotides* to *pentose sugars* + *phosphate* + *organic base*

Table 3.3.1 The main secretions associated with the small intestine

Endopeptidases and exopeptidases

As can be seen in table 3.3.1, the breakdown of proteins is brought about by two different groups of enzymes known as **endopeptidases** and **exopeptidases**. What are they, and what is their purpose?

To put it simply, endopeptidases break bonds within the polypeptide chains producing shorter peptides, whilst exopeptidases act only on the bonds at the very end of the peptide chain, thus releasing individual amino acids. Figure 3.3.13 shows this.

The value to the organism of having these two different types of protein-digesting enzymes is simple. Exopeptidases on their own would take a relatively long time to break down

Exopeptidases act only on the terminal peptide links in a peptide chain – for example, aminopeptidase will only hydrolyse the final link at the amino end of the molecule and carboxypeptidase will only hydrolyse the link at the carboxyl end. As a result the amino acids are released from the chains one at a time.

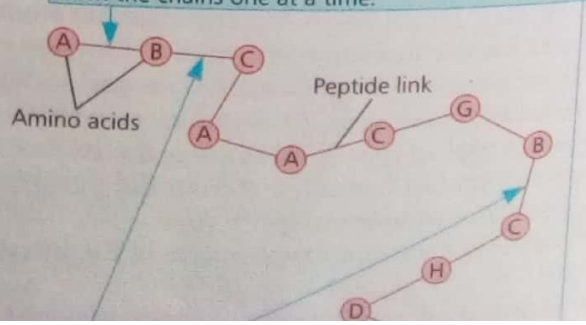

Table 8.3 Summary of digestive secretions and their action.

Secretion	*Source*	*Enzymes*	*Site of action*	*Optimum pH*	*Substrate*	*Products*
saliva	salivary glands	salivary amylase	buccal cavity	6.5–7.5	amylose in starch	maltose
gastric juice	stomach mucosa (gastric glands)	rennin** (in young)	stomach	2.00	casein	insoluble salt of casein
		pepsin**	stomach	2.00	proteins	peptides
		hydrochloric acid (not an enzyme)	stomach	–	pepsinogen	pepsin
					prorennin	rennin
membrane-bound enzymes in microvilli of small intestine	small intestine mucosa	amylase	microvilli of epithelium of small intestine	8.5	amylose	maltose
		maltase		8.5	maltose	glucose
		lactase		8.5	lactose	glucose + galactose
		sucrase		8.5	sucrose	glucose + fructose
		exopeptidases* (aminopeptidase		8.5	peptides and	aminoacids
		dipeptidase)		8.5	dipeptides	amino acids
		enterokinase	small intestine	8.5	trypsinogen	trypsin
pancreatic juice	pancreatic glands	amylase	small intestine	7.00	amylose	maltose
		endopeptidases* (trypsin**	small intestine	7.00	proteins / chymotrypsinogen	peptides / chymotrypsin
		elastase	small intestine	7.00	proteins	peptides
		chymotrypsin**)	small intestine	7.00	proteins	amino acids
		exopeptidase* (carboxypeptidase)	small intestine	7.00	peptides	amino acids
		lipase	small intestine	7.00	lipids	fatty acids + glycerol
bile	liver	bile salts (not enzymes)	small intestine	7.6–8.6	lipids	lipid droplets

*Exopeptidases split off terminal amino acids from proteins (polypeptides)

Endopeptidases break bonds between amino acids within proteins

Collectively these enzymes break up polypeptides into their constituent amino acids so that they can be absorbed by the villi of the ileum

Table 21B-1 Summary of Chemical Digestion

Location	Mouth		Stomach		Small intestine					
Digestive fluid	Saliva from salivary gland		Gastric juices from stomach lining		Bile from liver		Pancreatic juices from pancreas		Intestinal juices from intestinal lining	
Starch	AMYLASE	disaccharides (maltose)					AMYLASE (starch)	disaccharides (maltose)	MALTASE	monosaccharides (glucose)
								(sucrose)	SUCRASE	(fructose; glucose)
								(lactose)	LACTASE	(galactose; glucose)
Fat					BILE	emulsified fats	LIPASE	fatty acids and glycerol	LIPASE	fatty acids and glycerol
Protein			PEPSIN	protein fragments			TRYPSIN AND CHYMO-TRYPSIN	polypeptides	PEPTI-DASE	amino acids