Veterinary Bioscience: Digestive System

LECTURE 22
DIGESTION AND ABSORPTION

LECTURER

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INTENDED LEARNING OUTCOMES

At the end of this lecture, you should be able to:

- Describe the histology of the small and large intestine, and Identify different anatomical regions of the intestine in tissue specimens prepared for light microscopy.
- Describe the structure of the intestinal villus and of intestinal mucosal cells and explain the functional significance of their structure.
- Explain how proteins, carbohydrates and fats are digested and absorbed in the small intestine, and describe how brush border enzymes and contribute to the digestive process.
- Explain how absorption of sodium and secretion of chloride contribute to water balance in the intestines.
- Describe the role of secretory and absorptive cells in the crypt-villus unit and explain how disease processes can perturb the balance of secretion and absorption, resulting in diarrhoea.

KEY WORDS

Villus, crypt-villus unit, microvillus, brush border, goblet cell, crypt cell, duodenum, jejunum, ileum, colon, dipeptidase, disaccharidase, aminopeptidase, sucrase, lactase, micelle, chylomicron, oral rehydration therapy (ORT), lacteal.

LECTURE OVERVIEW

The small intestine is the site where digestion of foodstuffs is completed, and absorption occurs. The greatest proportion of absorption takes place in the duodenum- but ileal absorption is important particularly for absorption of bile salts, fat soluble vitamins and vitamin B12. There are specific absorption mechanisms for each of the major nutrients as well as for sodium. Clinically significant secretion of electrolytes also occurs in the small intestine.

The small and large intestines are differentiated structurally for their roles in digestion and absorption. Surface area is increased by the presence of folding (plicae and rugae), by the villus structure of the small intestinal mucosa and by the presence of microvilli on mucosal absorptive cells. The microvillus brush

border contains enzymes that catalyse the final breakdown of carbohydrates and peptides to absorbable units, and also the transport pumps required for absorption.

Intestinal secretion of chloride

Chloride is secreted by intestinal crypt cells, by means of an active transport process. The movement of chloride into the lumen is accompanied by sodium and water. The secretion of chloride is mediated by second messenger systems involving cAMP and cGMP. Changes in these second messenger levels induced by microbial pathogens can result in secretory diarrhoea.

Digestion and absorption of protein

The breakdown products of pancreatic proteases are amino acids and small peptides. These are split by dipeptidases bound to the brush border membrane, and amino acids are absorbed by a carrier mediated Na dependent secondary active transport process in the apical cell membrane.; the carrier is specific for each amino acid. Absorbed amino acids then move by diffusion down a concentration gradient into the blood stream.

Digestion and absorption of carbohydrate

Dietary carbohydrate is presented for absorption as the disaccharides: maltose, sucrose and lactose. Disaccharidases located in brush border facilitate their breakdown to monosaccharides. Glucose and galactose both move through the apical membrane via secondary active transport: a carrier on the luminal surface simultaneously transfers glucose against a concentration gradient, and Na+ down a concentration gradient from the lumen to the cell. The Na concentration gradient is established by basolateral Na+/K+ pump; no energy is directly used to move glucose up a concentration gradient. Cotransport is driven by Na+ gradient established by the Na/K pump. Glucose and galactose diffuse down a concentration gradient through the basolateral surface of cell; fructose is absorbed into the blood purely by facilitated diffusion.

Digestion and absorption of fat

Because of the insolubility of fat in water, fat must undergo physical and chemical transformation to facilitate absorption. Dietary fat in the form of triglycerides is emulsified by the detergent action of bile salts to form micelles, with increased surface area for pancreatic lipase activity. Lipase hydrolyses triglycerides to monoglycerides and free fatty acids, and the water insoluble products are carried in the interior of water-soluble micelles to the brush border. Monoglycerides and free fatty acids leave the micelle and passively diffuse through the luminal membrane. Within the cell, triglycerides are resynthesised, aggregate and are coated with lipoprotein to form water soluble chylomicrons that are extruded from the basal cell surface by exocytosis. Chylomicrons unable to enter blood capillaries, so enter lymphatic lacteals. Following feeding, lacteals are visible due to the “milky” character of the lymph within them.

Absorption of sodium

Absorption of sodium, that drives also the absorption of water from the gut, occurs in a number of ways. When the electrochemical gradient is favourable, sodium will diffuse down a concentration gradient into the cell. At other times, absorption of sodium is driven by a Na/K active transport pump on the basolateral cell membrane, that creates a favourable diffusion gradient across the apical cell membrane into the cell. In addition, Na entry to the cell occurs in a cotransport mechanism linked to both glucose and amino acid absorption, by means of the sodium linked glucose transport (SLGT) protein. This latter mechanism forms the basis of oral rehydration therapy with isotonic glucose solutions, as this cotransport may continue to function in intestinal disease states that cause diarrhoea.

Absorption in the large intestine

With the exception of the hind-gut fermenters, that are the topic of a later lecture, the largest proportion of water, and almost all nutrients are absorbed from the small bowel. Approximately 12% of water absorption occurs in the colon, but the efficiency of absorption is much higher here; (90% compared to 50% in the small intestine). In addition, water absorption from the large bowel is regulated by the presence of aldosterone responsive Na channels in the basal membrane of colonic mucosal cells.

FURTHER READING

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