Small Intestine Absorption

Absorption in the small intestine occurs in all three of its sections; the duodenum, jejunum and ileum. Three groups of nutrients undergo similar paths into the bloodstream. Carbohydrates and amino acids undergo active transport through the membrane into the epithelial cells because of size and charge. However, small lipids can passively diffuse into the epithelial cells because of the small size and similar composition to membranes. From the epithelial cells, these molecules travel to the intestinal capillaries and travel to the hepatic portal system, and to the liver for processing. Unlike these smaller molecules, large lipids must first be broken down for transport. They are broken into triglycerides, reformed as chylomicrons, and are transported by the lacteals through the lymphatic system.

PLAY PICMONIC

Characteristics

Carbohydrates Undergo Active Transport

Bread in Transporter

Only monosaccharides, glucose, galactose, and fructose can be absorbed by enterocytes. Glucose and galactose enter via SGLT1, a sodium-dependent transporter. Fructose, on the other hand, is absorbed through facilitated diffusion using GLUT5. Once inside the enterocytes, all three monosaccharides are transported into the bloodstream via GLUT2.

Fructose Undergoes Facilitated Diffusion

Fruit-toast through Face Diffuser

Fructose is a monosaccharide that undergoes facilitated diffusion for cellular uptake and absorption. Unlike glucose, which is transported via sodium-dependent active transport, fructose is absorbed in the small intestine through the GLUT5 protein, a facilitative transporter specific to fructose. Once inside enterocytes, fructose is transported into the bloodstream via GLUT2, enabling systemic distribution. This passive, carrier-mediated process allows fructose uptake without requiring energy expenditure, distinguishing it from other carbohydrate absorption mechanisms.

Amino Acids Undergo Active Transport

A-mean-ol'-lemon in Transporter

Amino acids must also undergo active transport into the epithelial cells of the small intestine because many of them are charged. This is important because they cannot passively be absorbed, as many amino acids go against an electrochemical gradient.

Iron Undergoes Active Transport

Iron in Transporter

Iron uptake happens in ferrous (Fe2+) via DMT1 (divalent metal transporter 1) in the duodenum. Regulated by hepcidin and ferroportin.

Water-Soluble Vitamins Undergo Active Transport

Water Viking-ship in Transporter

Water-soluble vitamins, including B-complex vitamins and vitamin C, are primarily absorbed in the small intestine through active transport mechanisms. This process involves specific carrier proteins or sodium-dependent transporters that facilitate their uptake across the intestinal epithelium. Some vitamins, such as vitamin B12, require specialized transport mechanisms, including intrinsic factor-mediated absorption in the ileum. Active transport ensures efficient absorption even at low luminal concentrations, allowing for proper physiological function and cellular metabolism.

Small Lipids Undergo Passive Diffusion

Small Lips through Pacifier Diffuser

Due to their small size and hydrophobic nature, short- and medium-chain fatty acids can passively diffuse through the lipid bilayer of enterocytes, while long-chain fatty acids require micelle formation and transporter-mediated absorption.

Epithelial Cells

E-pick Cells

The small intestine's epithelial cells (enterocytes) are the primary site of nutrient absorption. Water-soluble nutrients are transported into intestinal capillaries, while lipids are absorbed into lacteals before entering the bloodstream.

Intestinal Capillaries

Caterpillars

Intestinal capillaries, branching from the celiac trunk and mesenteric arteries, supply oxygenated blood to the small intestine and facilitate the transport of absorbed nutrients. Blood in these capillaries initially has low concentrations of nutrients, creating a concentration gradient that helps in the passive diffusion of some nutrients. However, many nutrients, such as glucose and amino acids, require active transport mechanisms for efficient absorption into the bloodstream. The nutrient-rich blood is then drained into the hepatic portal vein for processing in the liver.

Hepatic Portal Circulation Transports Absorbed Nutrients To The Liver

Happy-face Portal sends Sponge Nutrient-plates to Liver

The hepatic portal system is a crucial circulatory pathway that directs blood from the gastrointestinal tract and spleen to the liver for nutrient processing, detoxification, and metabolic regulation before entering the systemic circulation. This system ensures the body can effectively process absorbed substances, store nutrients, and maintain metabolic balance.

Liver Processes Absorbed Nutrients

Liver Processing Sponge Nutrient-plates

The liver is the central organ for processing many nutrients absorbed from the GI tract. For example, carbohydrates are converted into glucose, which the liver stores as glycogen or releases into circulation to maintain blood sugar levels. Amino acids are either incorporated into proteins, converted into glucose via gluconeogenesis, or used for energy production. Vitamins and minerals are also stored or modified for utilization. Not every molecule is transported to the liver; for example, long-chain fatty acids are absorbed into the lymphatic system, bypassing the liver initially. After entering the bloodstream, these lipids are eventually transported to the liver, where they are metabolized.

Large Lipids and Fat-Soluble Vitamins Transported as Chylomicrons

Large Lips and Bacon Viking-ship attached to Kite-mic

Bile salts emulsify long-chain fatty acids and fat-soluble vitamins (A, D, E, K) into micelles in the small intestine. These micelles are absorbed by enterocytes, where the long-chain fatty acids and fat-soluble vitamins are re-esterified into triglycerides and incorporated into chylomicrons. The chylomicrons are then transported via the lymphatic system, eventually entering circulation through the thoracic duct for delivery to tissues and processing by the liver.

Lacteals Transport Chylomicrons

Locked-eel eats Kite-mic

Lacteals are lymphatic capillaries in the villi of the small intestine that absorb dietary fats, particularly in the form of chylomicrons. These chylomicrons are transported through the lymphatic system and enter the bloodstream via the thoracic duct, which drains into the left subclavian vein.