

# Physiology of Digestion

## Lecture -IV

---

### Absorption from the Gastrointestinal tract

Ingestion and digestion are the first two phases of the physiological processes taking place in the alimentary canal. The third phase is absorption.

**Absorption from the mouth** – Normally there is no absorption takes place from the mouth, but a few drugs can be absorbed into the blood through the mucous membrane.

**Absorption from the stomach** – Absorption takes place to a limited degree in stomach. The only substance absorbed from the stomach are some water, glucose and ample amount of alcohol. These substances are absorbed through the wall of the stomach into the venous circulation.

**Absorption from the small intestine-** It is the main absorptive organ about 90% of the digested substances are absorbed here. The surface area of the intestine through which absorption can take place is tremendously increased by the circular folds of the mucous membrane and large no. of villi. Surface area is further increased by the microscopic folds, the microvilli formed on the surface of intestinal epithelial cells.

There are two general pathways for the transport of materials absorbed by the intestine. The veins of the hepatic portal system which lead directly to the liver and the lymphatic vessels of the intestinal area which finally leads to the blood by way of the lymphatic system and the thoracic duct.

Absorption mainly refers to the movement of nutrients, water and electrolytes from the lumen of the small intestine into the cell, then into the blood.

We will look at the digestion and absorption of the three main constituents of the food - carbohydrates, protein and lipids.

## Carbohydrates

### Digestion

There are three carbohydrate products which are absorbed by the small intestine; glucose, galactose and fructose.

Digestion of starch is initiated in the mouth, facilitated by salivary amylase. The majority of carbohydrate digestion occurs in the small intestine. The main enzyme is pancreatic amylase, which yields disaccharides from starch by digesting the alpha 1-4 glycosidic bonds.

The disaccharides produced (maltose, malt triose, and  $\alpha$ -dextrins) are all converted to glucose by brush border enzymes.

Disaccharides occurring naturally in food do not require amylase to break them down. Brush border enzymes (lactase, sucrase, trehalase) hydrolyse these compounds into molecules of glucose, galactose and fructose.

## Absorption

Two mechanisms are responsible for absorption of monosaccharides, active transport, against the concentration gradients and simple diffusion.

Glucose and galactose are absorbed across the apical membrane by secondary active transport (along with  $\text{Na}^+$ ) through the Sodium-Glucose cotransporter (SGLT1). Both glucose and galactose exit the cell via GLUT2 receptors across the basolateral membrane into the blood. Fructose enters the cell by facilitated diffusion via GLUT5 and is transported into the blood via GLUT2 receptors.

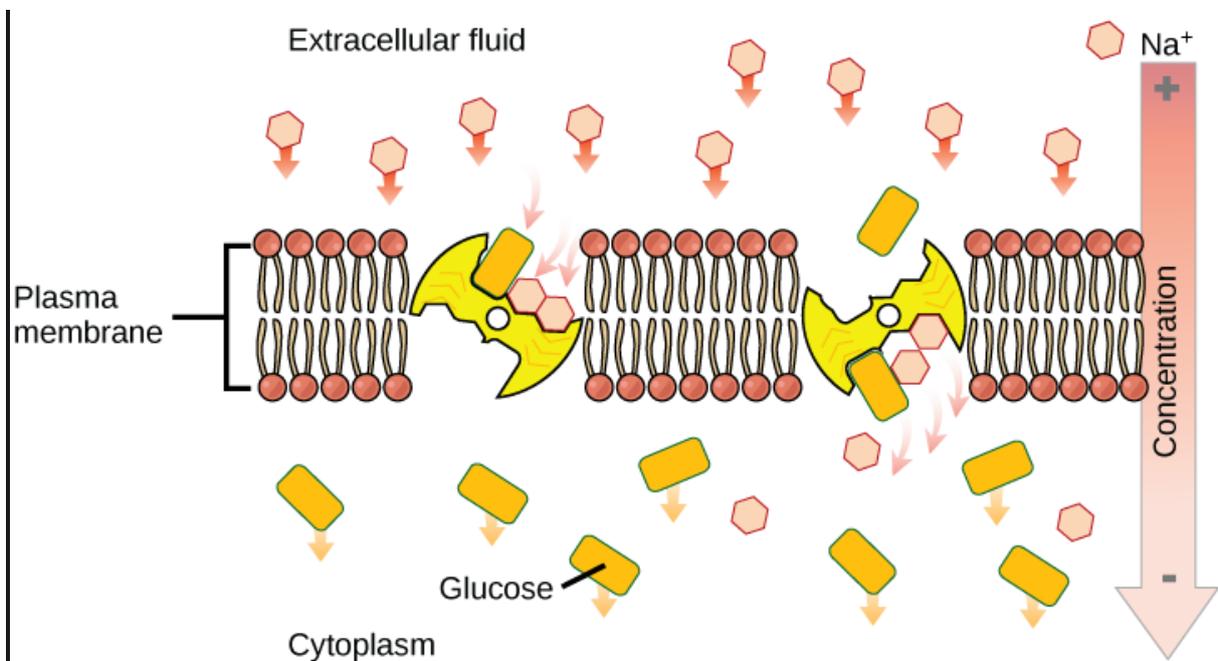


Fig 1 – Sodium moves down its concentration gradient, bringing in glucose to the the cell.

## Protein

### Digestion

Protein digestion begins in the stomach with the action of **pepsin**, which breaks protein into amino acids and oligopeptides. The process of digestion is completed in the small intestine with brush border and pancreatic enzymes. They split the oligopeptides into amino acids, dipeptides and tripeptides.

## Absorption

Amino acids are absorbed via a Sodium cotransporter, in a similar mechanism to the monosaccharides. They are then transported across the basolateral membrane via **facilitated diffusion**. Di and tripeptides are absorbed via separate  $H^+$  dependent cotransporters and once inside the cell are hydrolysed to amino acids.

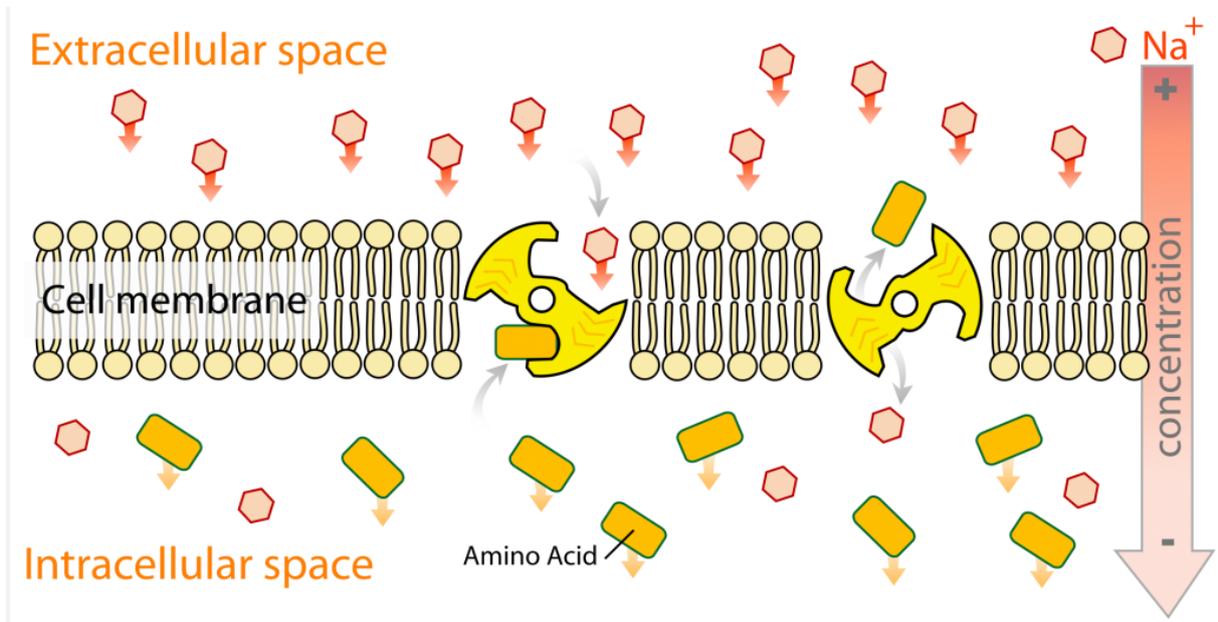


Fig 2 – The sodium-amino acid transporter, which is nearly identical to the sodium-glucose transporter.

## Lipids

### Digestion

Lipids are hydrophobic, and thus are poorly soluble in the aqueous environment of the digestive tract. Their digestion is started by lingual and gastric **lipases**, but this only digests 10% of ingested lipids.

The remainder of the lipids are digested in the small intestine. Here, bile aids digestion by **emulsifying** the fat globules into smaller chunks, called micelles, which have a much larger surface area.

Pancreatic lipase, phospholipase A2 and cholesterol ester hydrolase (3 major enzymes involved in lipid digestion) hydrolyse the **micelles**, breaking them down into fatty acids, monoglycerides, cholesterol and lysolecithin.

### Absorption

The products from digestion are released at the apical membrane and diffuse into the enterocyte. Inside the cell, the products are re-esterified to form the original lipids, triglycerides, cholesterol and phospholipids. The lipids are then packaged inside apoproteins to form a **chylomicron**. The chylomicrons are too large to enter circulation, so they enter lymphatic system via lacteals.

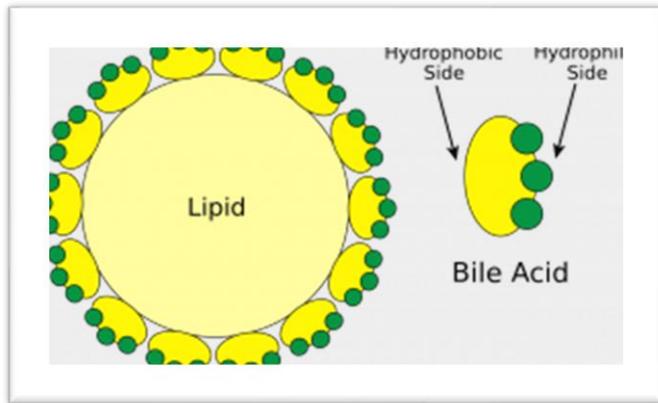


Fig 3 – The action of bile acids. By enveloping the lipid, the bile enhances absorption.

## Water Absorption

The average adult usually ingests 1-2 L of water each day, but the fluid load to the small intestine is 9 to 10 L, 8 to 9 L being added by secretions of the GI system.

Most absorption of water and electrolytes occurs in the **small intestine**, with some water absorbed in the **colon** as well. Water absorption is dependent on the absorption of solutes such as ( $\text{Na}^+$  and  $\text{Cl}^-$ ).  $\text{Na}^+$  is absorbed from the intestinal lumen, most use the cotransport with glucose and amino acids and the  $\text{Na}^+/\text{H}$  exchange, which allow  $\text{Na}^+$  ions to move from the lumen into the enterocyte.  $\text{Na}^+$  is rapidly removed from the enterocyte via the  $\text{Na}^+$  pumps, allow water via osmosis to follow either transcellularly or paracellularly (between the tight junctions of the enterocytes). Water as well as  $\text{Na}^+$  ions can then diffuse into the capillaries.

## Function of the large Intestine

1. **secretion**- The large intestine secretes mucin which lubricates the faeces and facilitate their passage through rectum and anus.
2. **Absorption**- Water is absorbed by the wall of the colon. The absorption of water from the large intestine helps in maintaining the body water.
3. **Excretion**- Excess of calcium, iron and drugs of the heavy metal are excreted by the large intestine.
4. Bacterial decomposition of cellulose.