Digestion

- The major foods on which the body lives can be classified as ***carbohydrates, fats and proteins***
  - small quantities of vitamins and minerals

- They generally **cannot be absorbed in their natural forms** – useless as nutrients without preliminary digestion

Digestion of Carbohydrates

- **sucrose**, which is the **<u>disaccharide</u>** known popularly as ***cane sugar***;

- **lactose**, which is a **<u>disaccharide</u>** found in ***milk***;

- **starches**, which are **<u>large polysaccharides</u>** present in almost all nonanimal foods - particularly in ***potatoes and the different types of grains***

- Other carbohydrates ingested to a slight extent are **amylose, glycogen, alcohol, lactic acid, pyruvic acid, pectins, dextrins**

- **Cellulose -** noenzymes

Digestion of Carbohydrates

- Saliva – ptyalin – alpha amylase – parotid gland

- Hydrolyzes **starch** into the disaccharide **maltose**

- the food remains in the ***mouth*** only a **short time** - not more than 5 per cent of all the starches will be hydrolyzed

- starch digestion sometimes **continues in the body and fundus** of the ***stomach*** for as long as 1 hour before the food becomes mixed with the stomach secretions

- Salivary amylase activity blocked – 40 per cent starches to maltose

Digestion of Carbohydrates

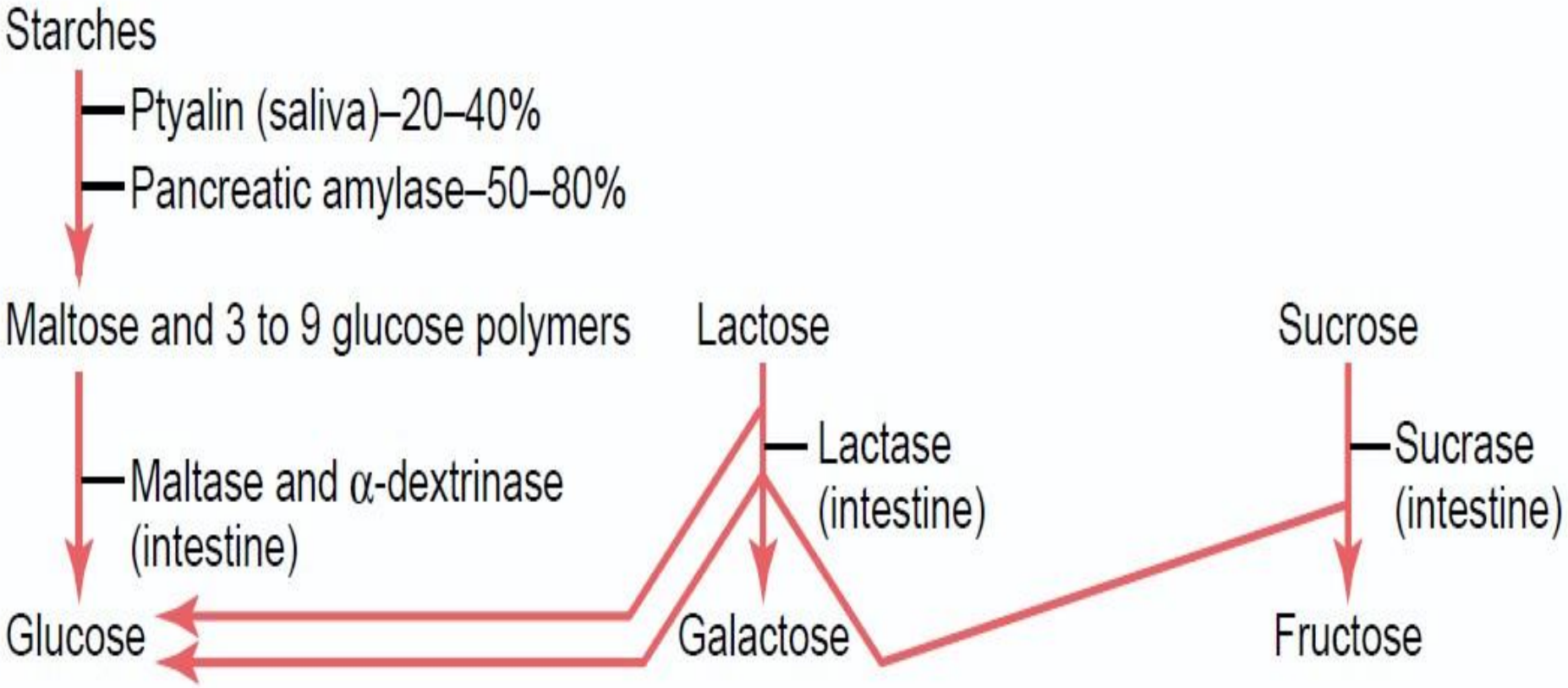
- ***Pancreatic*** Alpha amylase – more powerful than salivary amylase – maltose

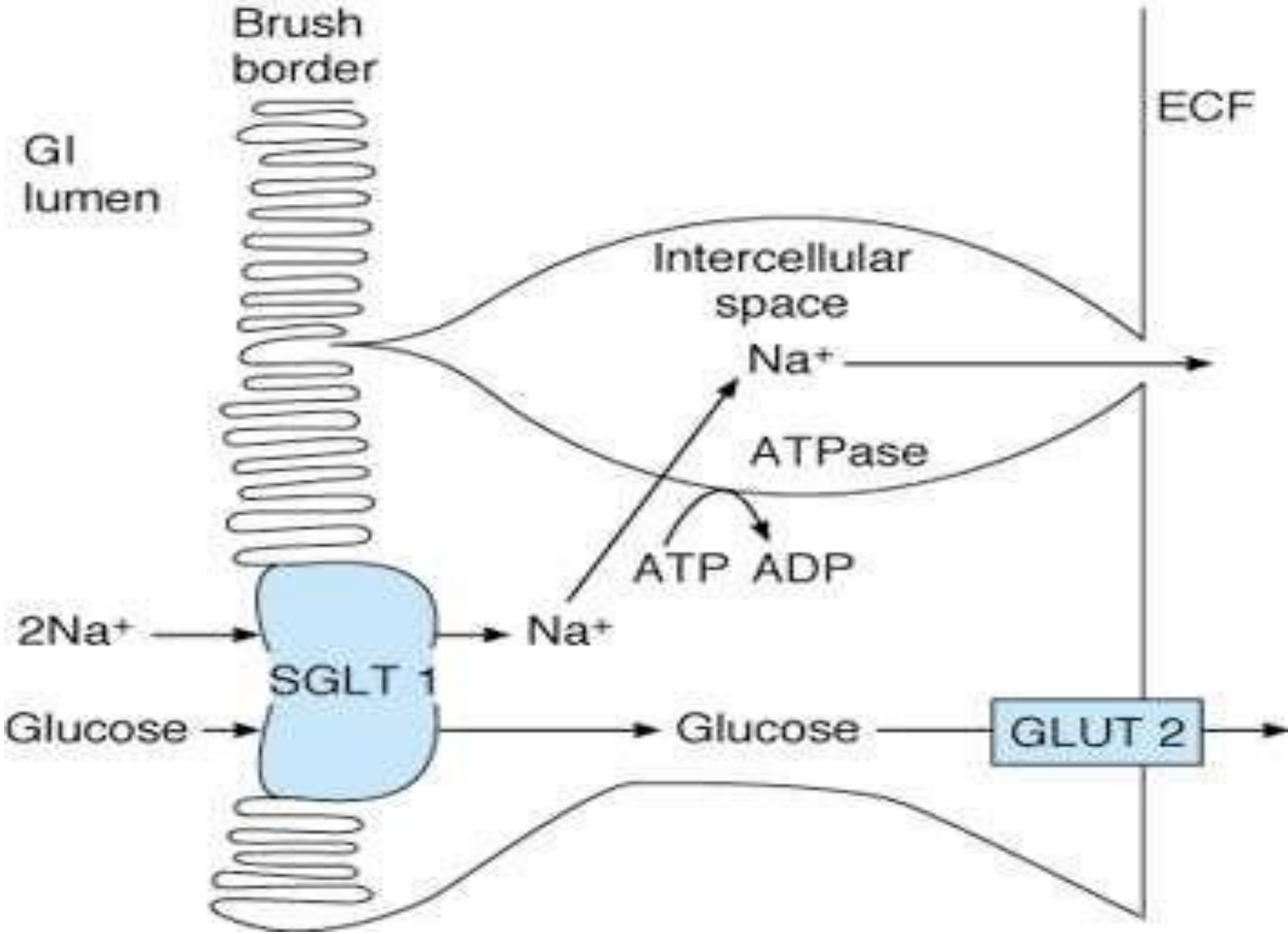
- enterocytes lining the villi of the ***small intestine***

  contain four enzymes (lactase, sucrase, maltase and alpha - dextrinase),

  - which are capable of splitting the disaccharides
  - lactose – **glucose** +galactose (10 per cent),
  - Sucrose - **glucose** +fructose (10 per cent),
  - Maltose - **glucose + glucose (80 per cent)**

  - Final product – **water soluble monosaccharides** – absorbed into portal blood


Starches
Ptyalin (saliva)–20–40%
Pancreatic amylase–50–80%
Maltose and 3 to 9 glucose polymers
Lactose
Sucrose
Maltase and α-dextrinase (intestine)
Lactase (intestine)
Sucrase (intestine)
Glucose
Galactose
Fructose


Brush border
GI lumen
ECF
Intercellular space
Na+
ATPase
ATP ADP
2Na+
Na+
SGLT 1
Glucose
Glucose
GLUT 2

Digestion of Proteins

- The dietary proteins are chemically long chains of amino acids bound together by **peptide linkages**

- ***Stomach*** – pepsin – HCL – **digest collagen** - meat

- pepsin **only initiates** the process of protein digestion, usually providing only 10 to 20 per cent of the total protein digestion to convert the protein to ***proteoses, peptones and a few polypeptides***

- major proteolytic ***pancreatic*** enzymes: trypsin, chymotrypsin, carboxypolypeptidase and proelastase

Digestion of Proteins

- Both **trypsin and chymotrypsin** split protein molecules into **small polypeptides**;

- **Carboxypolypeptidase** then cleaves **individual amino acids** from the carboxyl ends of the polypeptides

- **Proelastase**, in turn, is converted into **elastase**, which then **digests elastin fibers** that partially hold meats together.

- Only a small percentage of the proteins are digested all the way to their constituent amino acids by the ***pancreatic juices***. Most remain as **dipeptides and tripeptides**

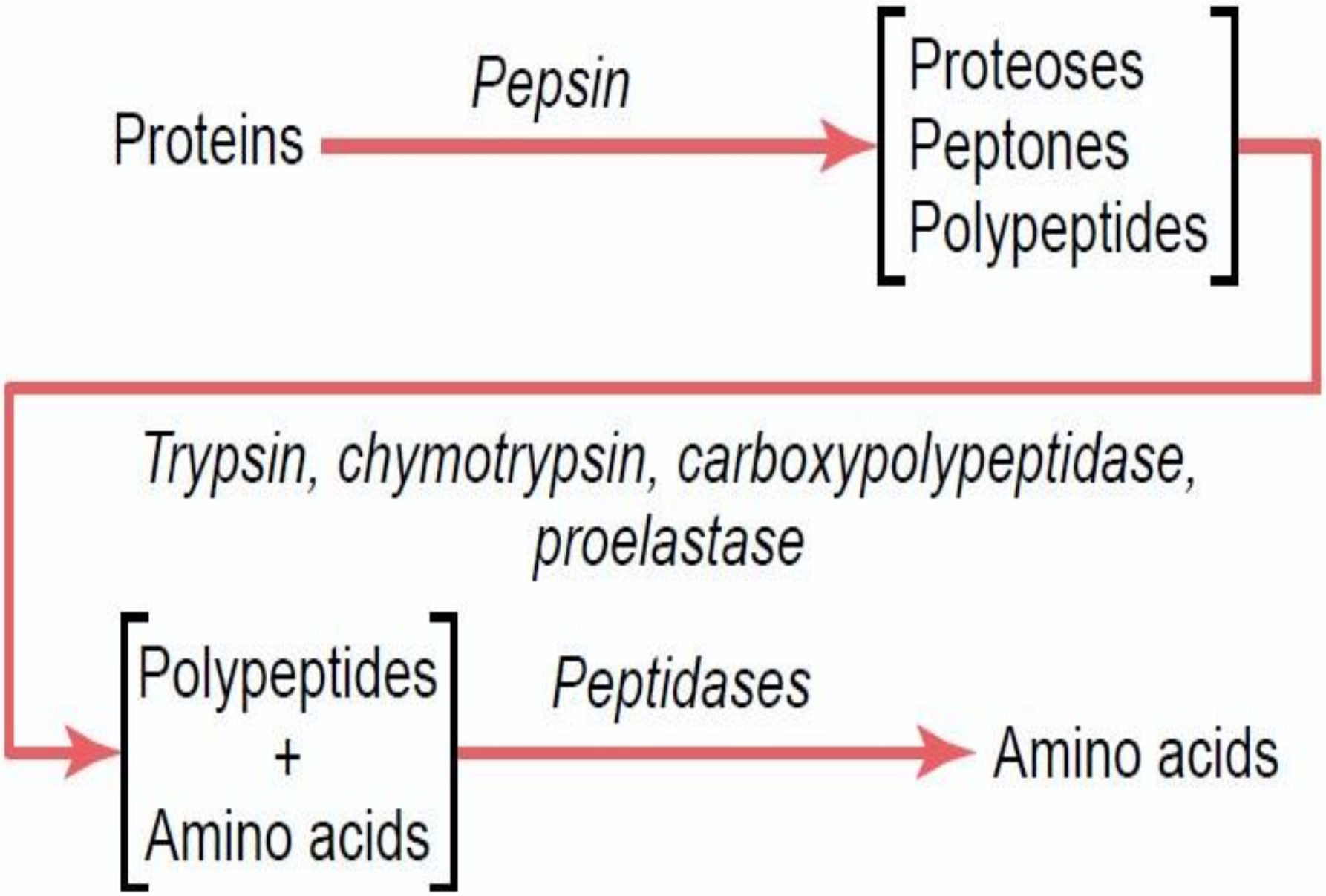
Digestion of Proteins

- **enterocytes** that line the villi of the small intestine, mainly in the <u>duodenum and jejunum</u>

- These cells have a **brush border that consists of hundreds of microvilli** projecting from the surface of each cell – ***<u>peptidases</u>***

- ***aminopolypeptidase and dipeptidases*** – larger *polypeptides* into *tripeptides* and *dipeptides* and a few into *amino acids*

- Dipeptides and tripeptides are easily transported through the microvillar membrane **to the interior of the enterocyte** – peptidase – amino acids


Proteins
Pepsin
Proteoses
Peptones
Polypeptides
Trypsin, chymotrypsin, carboxypolypeptidase, proelastase
Polypeptides
+
Amino acids
Peptidases
Amino acids

Absorption of Proteins

- in the form of dipeptides, tripeptides & free amino acids

- **sodium co-transportmechanism**

- *secondary active transport*

- *Few amino acids via **facilitated diffusion***

- **five types of transport proteins** for transporting amino acids and peptides have been found in the luminal membranes of intestinal epithelial cells

Digestion of Fats

- most abundant fats of the diet are the neutral fats, also known as **triglycerides**, each molecule of which is composed of a ***glycerol nucleus and three fatty acid side chains***

- small quantities of phospholipids, cholesterol and cholesterol esters

- A small amount of triglycerides is digested in the ***stomach*** by ***lingual lipase*** that is secreted by lingual glands in the mouth and swallowed with the saliva

- less than 10per cent and generallyunimportant

Digestion of Fats

- The first step in fat digestion is **physically to break the fat globules into very small sizes** so that the water-soluble digestive enzymes can act on the globule surfaces.

- This process is called ***emulsification of the fat***, and it begins by **persistlasis in the stomach** to mix the fat with the products of stomach digestion.

- Then, most of the emulsification occurs in the **duodenum** under the influence of bile - large quantity of ***bile salts as well as the phospholipid lecithin.***

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Digestion of Fats

- The **lipase enzymes are water-soluble compounds** and can attack the fat globules only on their surfaces

- enzyme for digestion of the triglycerides is ***pancreatic lipase***

- the enterocytes of the small intestine contain ***enteric lipase***

- Most of the triglycerides of the diet are split by pancreatic lipase into free fatty acids and 2-monoglycerides

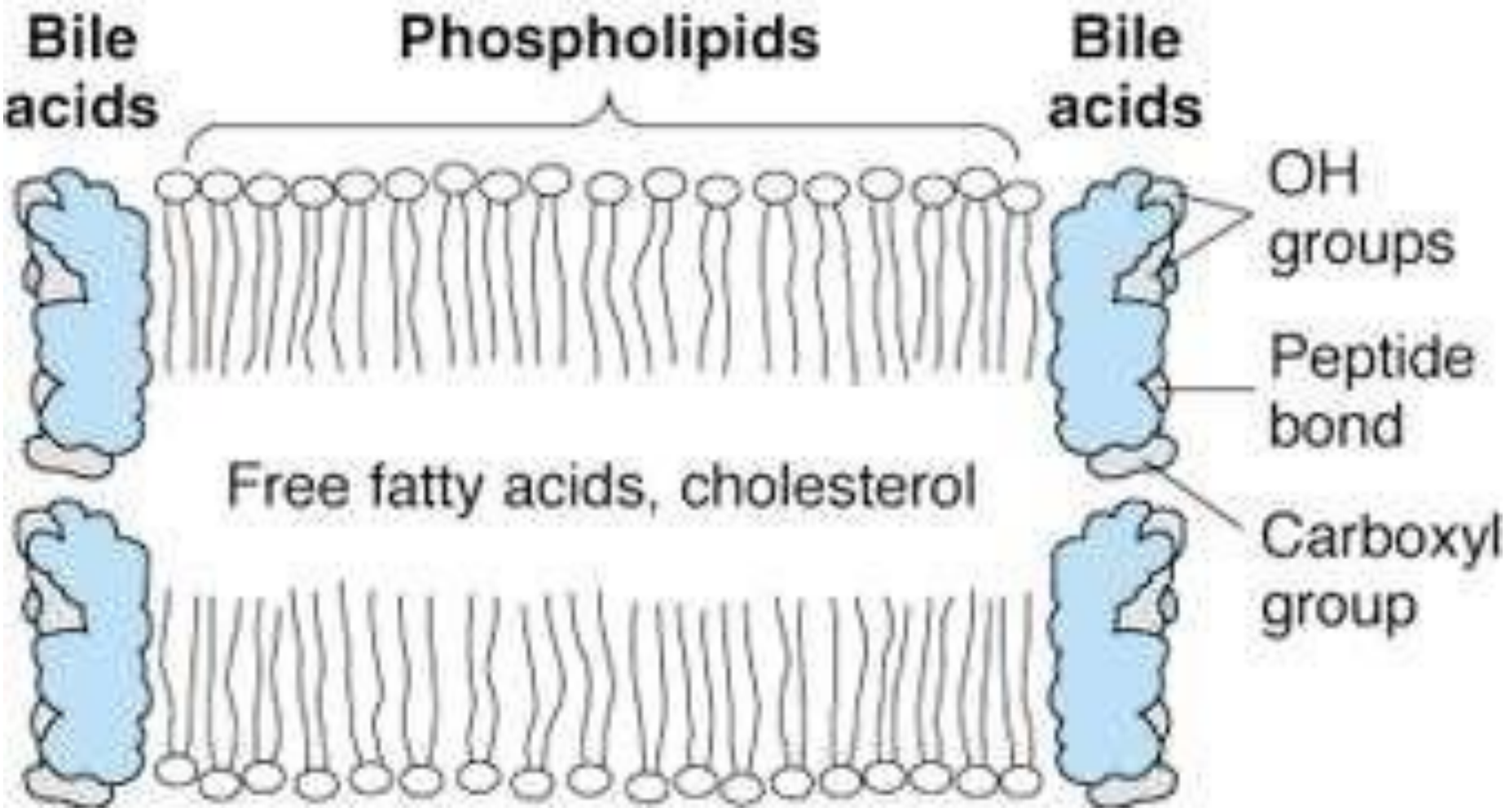
Digestion of Fats

- **Bile salts**, when in high enough concentration in water, have the propensity to form ***micelles***, which are small spherical, cylindrical globules

- 3 to 6 nanometers in diameter composed of 20 to 40 molecules of bile salt

- **Inside** fats – **outside** surface water soluble

- The bile salt micelles also act as a **transport medium to carry the monoglycerides and free fatty acids** - relatively insoluble, to the brush borders of the intestinal epithelial cells


Bile acids
Phospholipids
Bile acids
OH groups
Peptide bond
Free fatty acids, cholesterol
Carboxyl group

Digestion of Fats

- Bile salts released back into the chyme & again **reused**

- the enzyme ***cholesterol ester hydrolase*** to hydrolyze the cholesterol ester,
- ***phospholipaseA2*** to hydrolyze the phospholipid

- The bile salt micelles play the same role in **"ferrying" free cholesterol and phospholipid molecule** that they play in "ferrying" monoglycerides and free fatty acids

- no cholesterol is absorbed without this function of the ***micelles***

Absorption of Fats

After entering the epithelial cell, the fatty acids and monoglycerides are taken up by the cell's **smooth ER**

↓

they are mainly used to form **new triglycerides** that are subsequently released in the form of ***chylomicrons*** through the base of the epithelial cell,

↓

flow upward through the ***thoracic lymph duct*** and empty into the circulating blood

- **short and medium chain fatty acids (more water-soluble)** are absorbed directly into the portal blood

Absorption of Proteins

- in the form of dipeptides, tripeptides & free amino acids

- **sodium co-transportmechanism**

- *secondary active transport*

- *Few amino acids via **facilitated diffusion***

- **five types of transport proteins** for transporting amino acids and peptides have been found in the luminal membranes of intestinal epithelial cells

Absorption of Fats

- the **micelles perform a "ferrying" function** that is highly important for fat absorption

- In the presence of an abundance of bile micelles, about **97 per cent** of the fat is absorbed

- in the absence of the bile micelles, only **40 to 50 per cent** can be absorbed