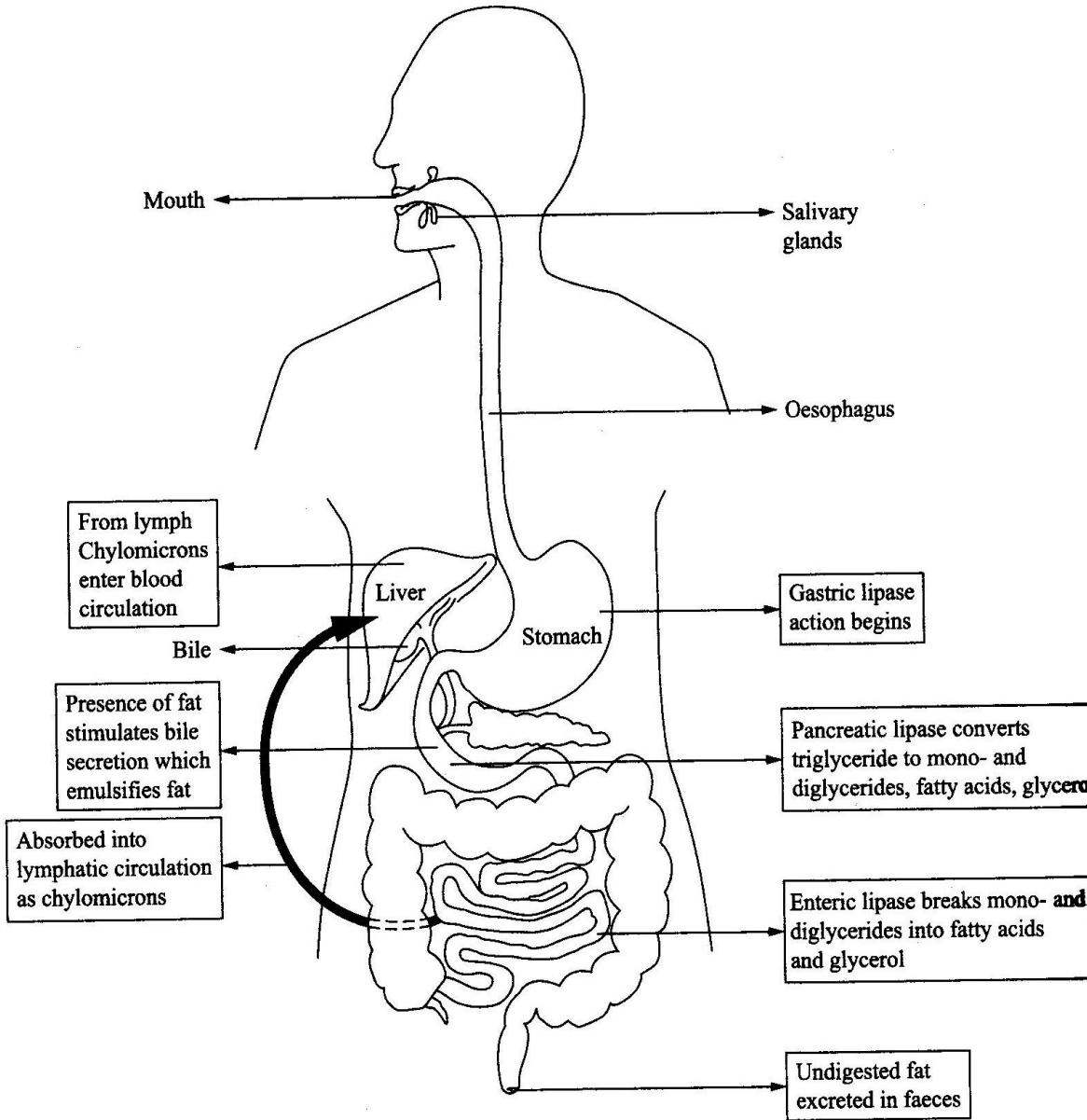


4. DIGESTION AND ABSORPTION OF LIPIDS

INTRODUCTION

- Foods are enzymatically digested to prepare them for absorption.
- During digestion in the gastrointestinal tract of mammals, the three major nutrients (carbohydrates, lipids, and proteins) undergo enzymatic hydrolysis into their building block components.
- This is necessary for their absorption, since the cells lining the intestine are able to absorb them into the bloodstream only as relatively small molecules.
- Lipids must be hydrolyzed into fatty acids and glycerol.

Digestion and absorption of fat



2 Digestion

- The digestion of triglycerides begins in the small intestine. In this region the zymogen, prolipase is secreted by the pancreas (Fig.4.1).
- There it is converted into active lipase, which in the presence of bile salts and a special protein called colipase, binds to droplets of triglycerides and catalyzes the hydrolytic removal of one or both of the outer fatty acid residues.
- Monoglycerides remain unhydrolyzed.

- The fatty acids and the uncleaved glycerides are emulsified into fine droplets by peristalsis, the churning action of the intestine, aided by the detergent effect of the bile salts and the monoglycerides, which are amphipathic molecules.
- Phospholipids are split by phospholipases to the acyl chains, glycerol and choline.
- Cholesterol esters are converted to cholesterol and free fatty acids

Absorption

- The fatty acids, glycerol and monoglycerides, in these droplets are absorbed by intestinal cells, where they are largely reassembled into triglycerides.
- The free fatty acids are activated by thiokinase in the presence of coenzyme A and ATP for the resynthesis of triglyceride.
- Some free glycerol passes directly to the lymph vessel.
- The others will be activated by glycerokinase in the presence of ATP to form glycerol 3 phosphate and combine with acyl CoA to form triglycerides.

- All the long chain fatty acids present are reincorporated into the triglycerides.
- The triglycerides do not pass into the blood capillaries but into the small lymph vessels in the villi.
- The cholin from phospholipids may be absorbed and sent to liver via lymph vessels.
- Cholesterol is absorbed into the lymphatic vessels and converted into cholesterol esters and transported.

Chylomicrons

The lymph draining the small intestine, called chyle.

It has a milky appearance after a fat-rich meal, due to the suspended chylomicrons, droplets of highly emulsified triglycerides, about $1\mu\text{m}$ in diameter.

Chylomicrons contain triglycerides, free and esterified cholesterol; have a hydrophilic coat of phospholipids and a special protein, which function to keep the chylomicrons suspended.

The chylomicrons pass from the thoracic duct into the subkavian vein and then to liver.

Emulsification

The emulsification and digestion of lipids in the small intestine is facilitated by the bile salts.

The major human bile salts are sodium glycocholate and sodium taurocholate, derivative of cholic acid, the most abundant of four major human bile acids.

The bile salts are powerful emulsifying agents secreted by the liver into the bile, which empties into the upper portion of the small intestine.

After the fatty acids and monoglycerides of the emulsified fat droplets have been absorbed in the lower small intestine, the bile salts aiding this process are also reabsorbed.

They return to the liver, to be used over again.

METABOLISM OF LIPIDS

- a) Metabolism of Triglycerides
- b) Metabolism of fatty acids

a) Metabolism of Triglycerides

- Triglycerides are first converted to fatty acids and glycerol mostly in adipose tissue.
- The fatty acids are released into the plasma where they combine with serum albumin.
- Long chain fatty acids are oxidized in liver, heart, kidney, muscle, lung, brain and adipose tissue.
- Glycerol is utilized by liver, kidney, intestine and lactating mammary gland where the activating enzyme glycero kinase is present.

b) Metabolism of fatty acids

The fatty acids components of the lipids entering the liver also have several different pathways.

1. Oxidation to CO_2 with ATP production

Free fatty acids may be activated and oxidized to yield **acetyl-CoA** and ATP via **glycolysis**.

The **acetyl-CoA** is oxidized via the **citric acid cycle** to yield ATP by **oxidative phosphorylation**.

Fatty acids are the major oxidative fuel in the liver.

2. Biosynthesis of cholesterol and bile salts

- Some of the **acetyl-CoA** derived from **fatty acids** (and from glucose) will be used as the major precursor for the biosynthesis of **cholesterol**,
- Cholesterol is the precursor of the **bile acids** and **bile salts**, which are essential for the digestion and absorption of lipids.

3.Biosynthesis of plasma lipoproteins

Fatty acids are also used as precursors for the synthesis of the lipid portion of the plasma lipoproteins.

Lipoproteins carry lipids to adipose or fat tissue for storage as triglycerides.

4. Formation of plasma free fatty acids

Free fatty acids become bound to serum albumin and are carried via the blood to the heart and skeletal muscles, which absorb and oxidize free fatty acids as major fuel.

5. Formation of ketone bodies

Excess acetyl-CoA released on oxidation of fatty acids and not required by the liver is converted into the ketone bodies, acetoacetate and D-β-hydroxy butyrate, which are circulated via the blood to peripheral tissues, to be used as fuel for the citric acid cycle.

The ketone bodies may be regarded as a transport form of acetyl groups.

They can supply significant fraction of the energy of some peripheral tissues, up to one-third in the case of the heart.

Metabolism of Fatty acids

