

Lipid Metabolism in the Liver and Its Role in Fat Digestion



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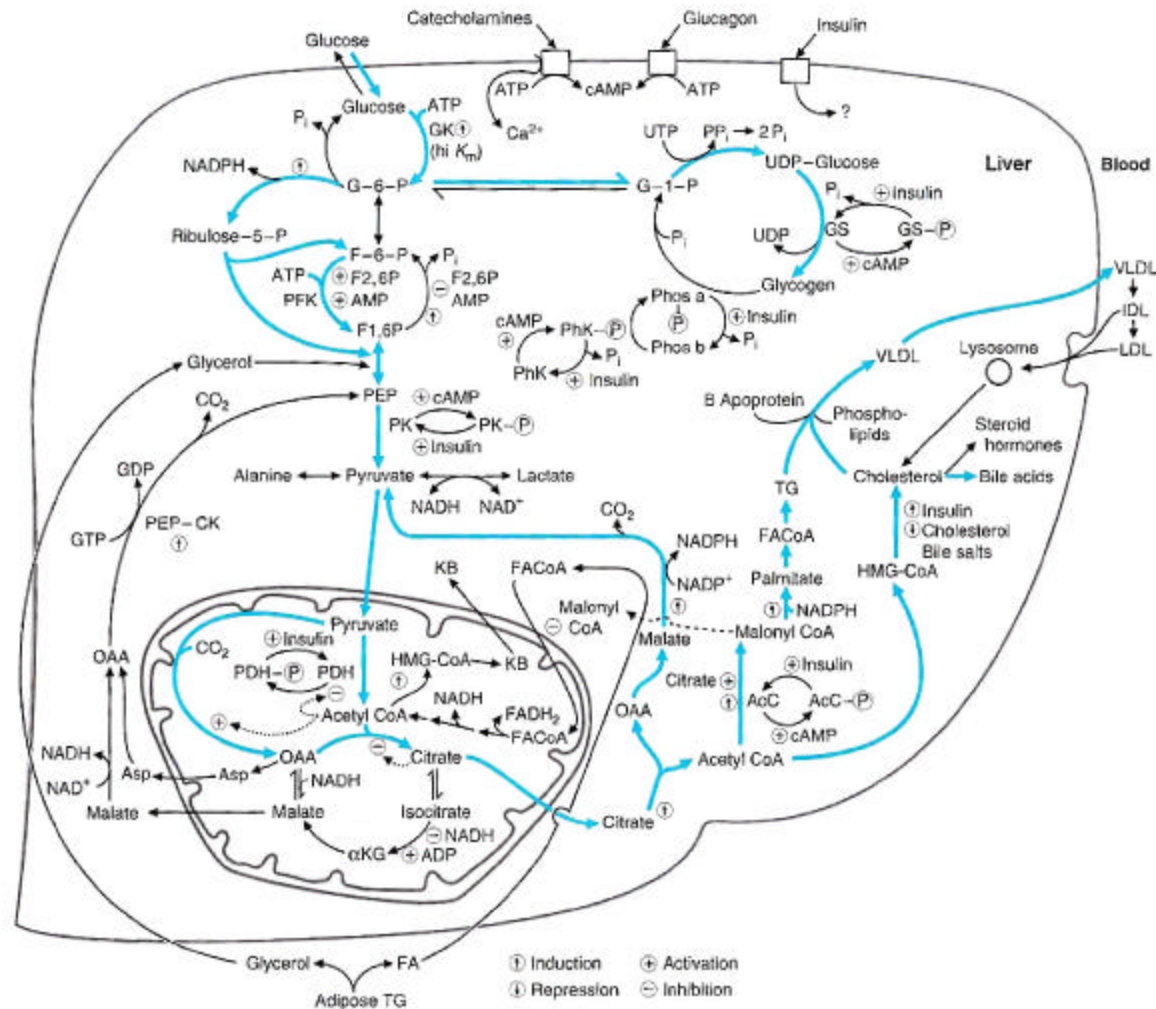
Fat Metabolism in Action!!

Lipid and Carbohydrate Metabolism in the Liver

In the fed state, carbohydrate can be converted to fat and exported via VLDL

In the fasted state, fatty acids are oxidized to produce energy and ketone bodies are exported as fuel for other tissues

Cholesterol is the precursor of bile acids that are used in fat digestion in the gut



Marks

Fig. 36.11. Regulation of carbohydrate and lipid metabolism in the liver. Solid blue arrows indicate the flow of metabolites in the fed state. Solid black arrows indicate the flow during fasting. G = glucose; GK = glucokinase; F = fructose; PFK = phosphofruktokinase-1; PEP = phosphoenolpyruvate; PK = pyruvate kinase; OAA = oxaloacetate; α KG = α -ketoglutarate; GS = glycogen synthase; Phos = glycogen phosphorylase; PhK = phosphorylase kinase; AcC = acetyl CoA carboxylase; FA = fatty acid or fatty acyl group; TG = triacylglycerol; circled P = phosphate group.

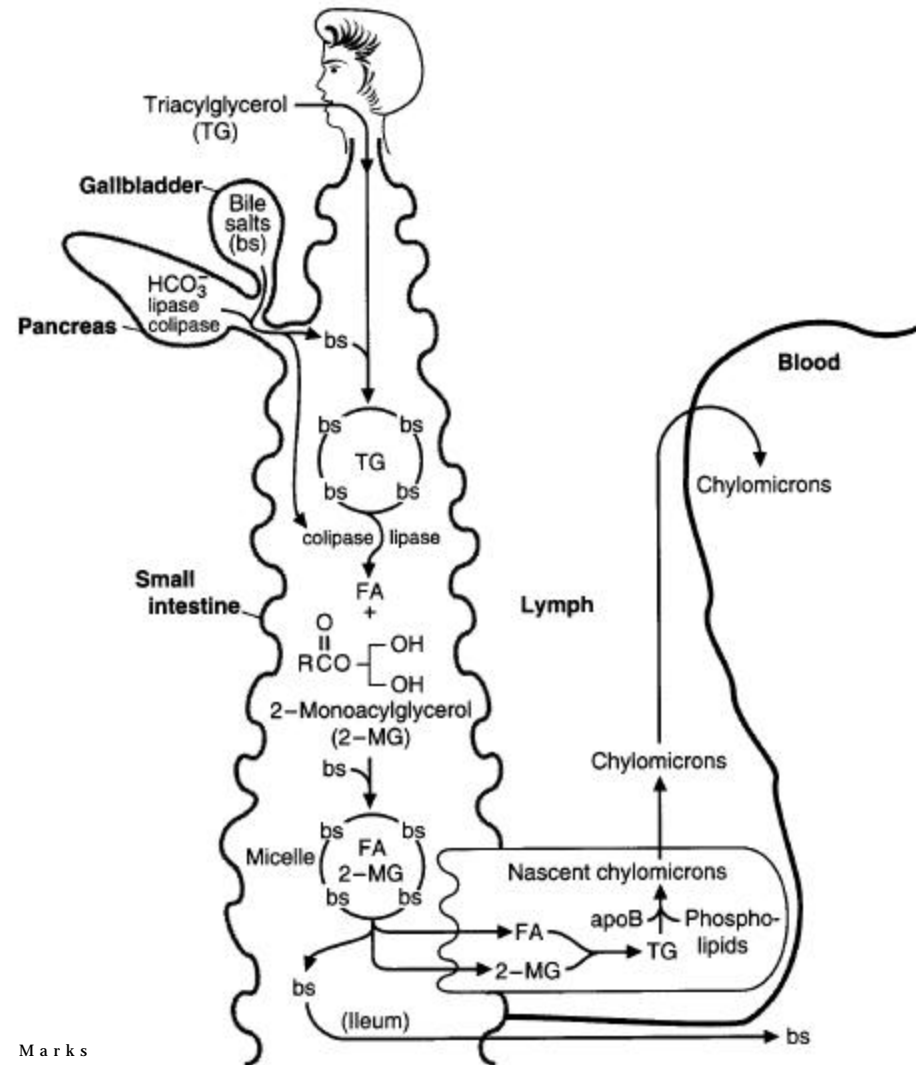
enolpyruvate; PK = pyruvate kinase; OAA = oxaloacetate; α KG = α -ketoglutarate; GS = glycogen synthase; Phos = glycogen phosphorylase; PhK = phosphorylase kinase; AcC = acetyl CoA carboxylase; FA = fatty acid or fatty acyl group; TG = triacylglycerol; circled P = phosphate group.

Lipid Digestion

Digestive enzymes from the pancreas are activated by bile salts to convert TG to fatty acids and 2-MG

Intestinal cells resynthesize TG and export chylomicrons into circulation

Most of the bile salts are returned to the liver for reuse



Marks

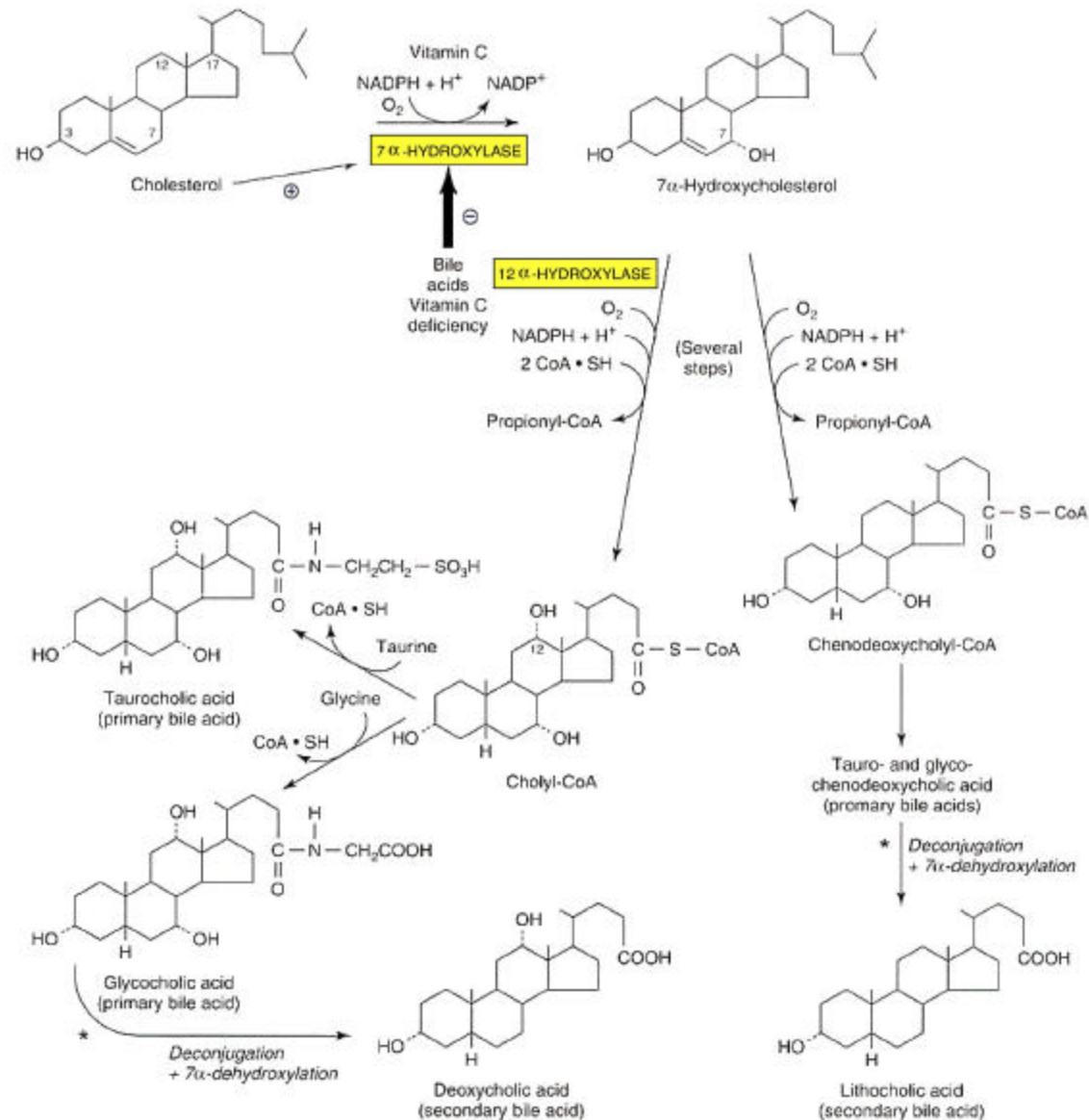
Fig. 32.8. Digestion of triacylglycerols in the intestinal lumen. TG = triacylglycerol; bs = bile salts; FA = fatty acid; 2-MG = 2-monoacylglycerol.

Bile Acids and Bile Salts

Bile acids and bile salts are made in the liver from cholesterol

The gall bladder delivers bile salts to the gut for emulsification

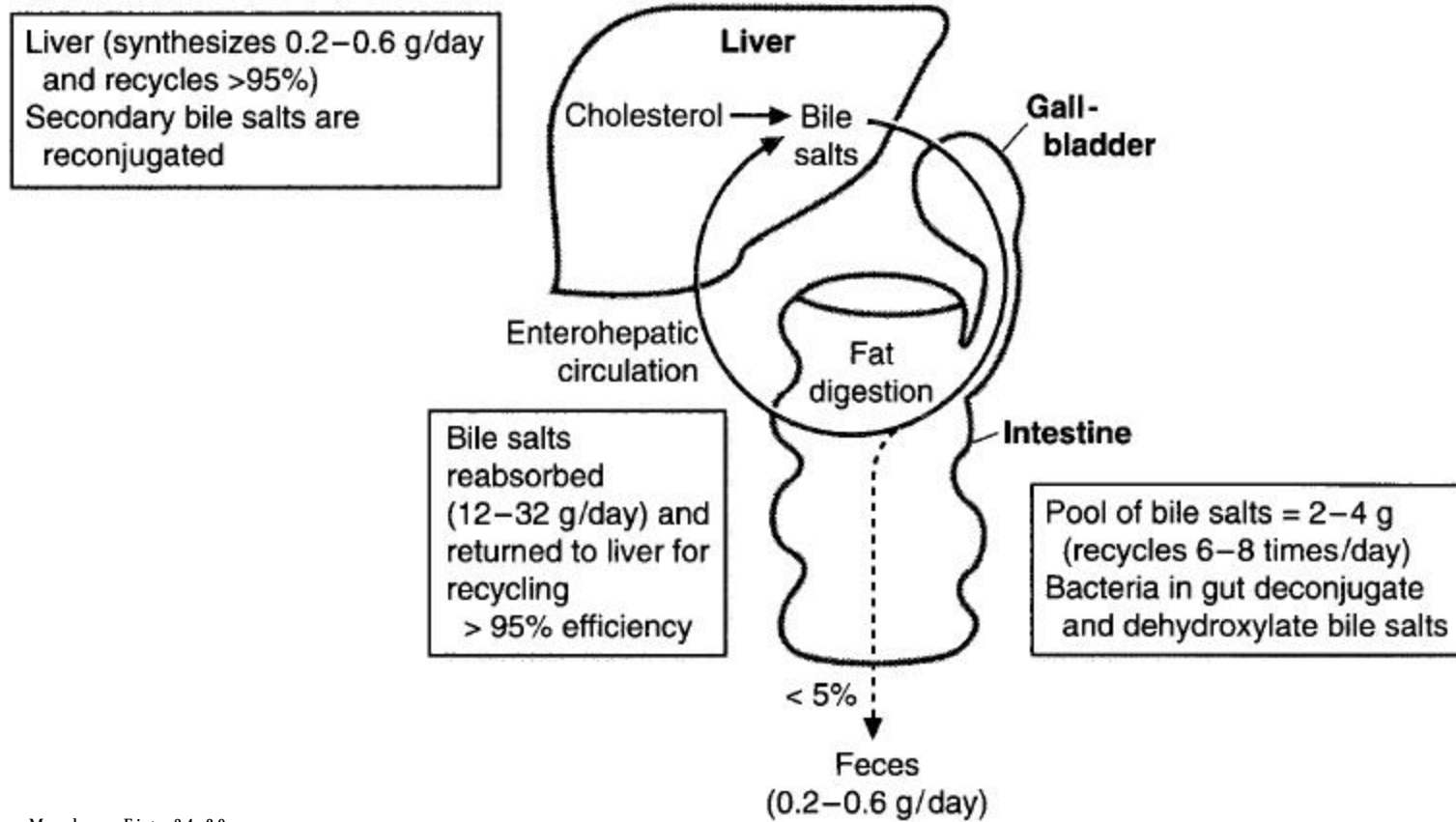
Bacteria modify the bile salts and most is reabsorbed by intestinal cells



Harper's

Figure 28-7. Biosynthesis and degradation of bile acids. *Catalyzed by microbial enzymes.

Enterohepatic Circulation



Solubility of Cholesterol in Bile

Meisenberg & Simmons

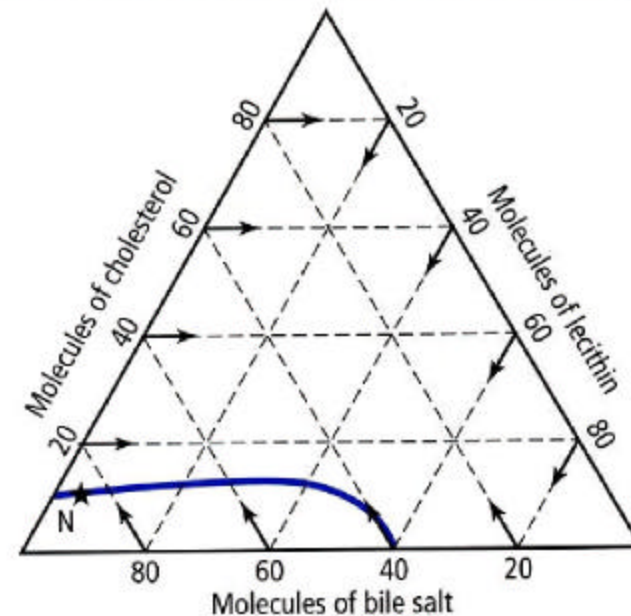
TABLE 19.2

Approximate composition of hepatic bile and bladder bile

Component	Hepatic bile	Bladder bile
Total solids	2.5%	10%
Inorganic salt	0.85%	0.85%
Bile acids	1.2%	6%
Cholesterol	0.06%	0.4%
Lecithin	0.04%	0.3%
Bile pigments	0.2%	1.5%
pH	7.4	5.0-6.0

FIG. 19.11

Solubility of cholesterol in the presence of bile acids and phosphatidylcholine ("lecithin"). If the relative composition of bile is above the blue line, the system is supersaturated with cholesterol, and cholesterol is likely to precipitate. A total lipid concentration of 10% is assumed. Point N represents a "normal" composition of bladder bile, with 5 mol% lecithin, 85 mol% bile acid, and 10 mol% cholesterol.



Overview of Cholesterol Transport

Cholesterol is esterified intracellularly by acy-CoA: cholesterol acytransferase or by lecithin: cholesterol acytransferase in lipoproteins

Chylomicrons pick up proteins from HDL

The liver is the major organ in which cholesterol is processed

Lipoproteins carry TG and cholesterol through the circulatory system

BOX 19.7

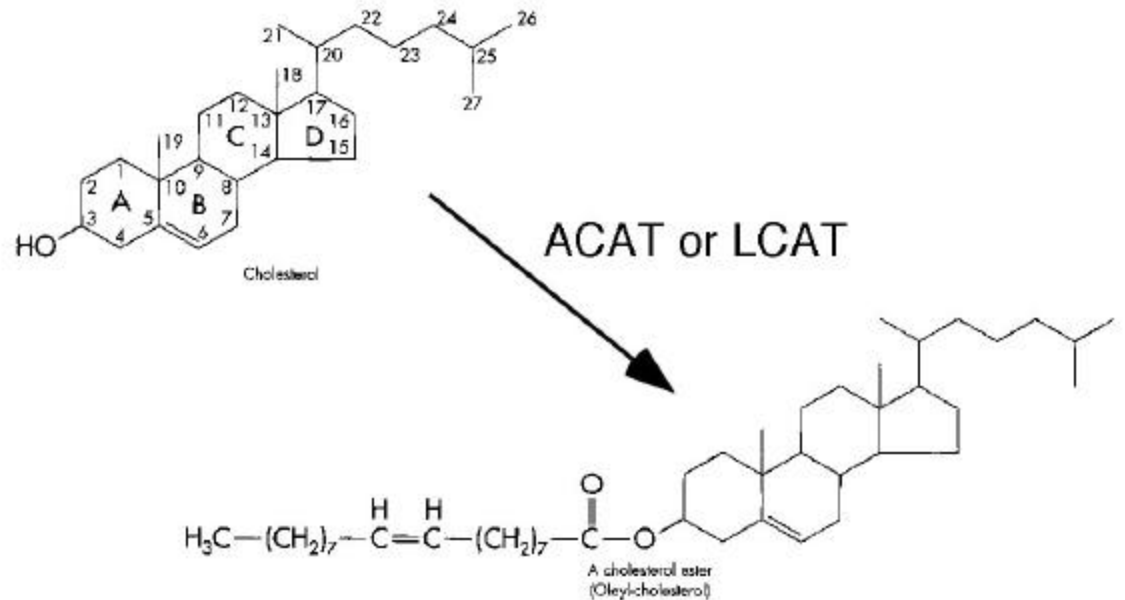
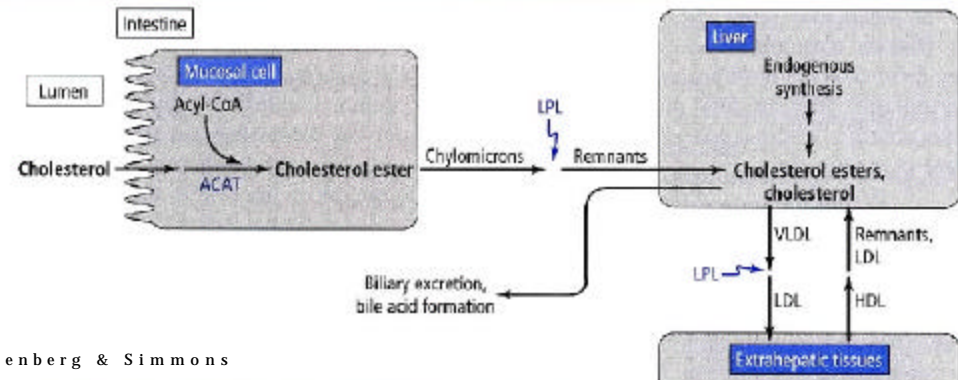


FIG. 19.5

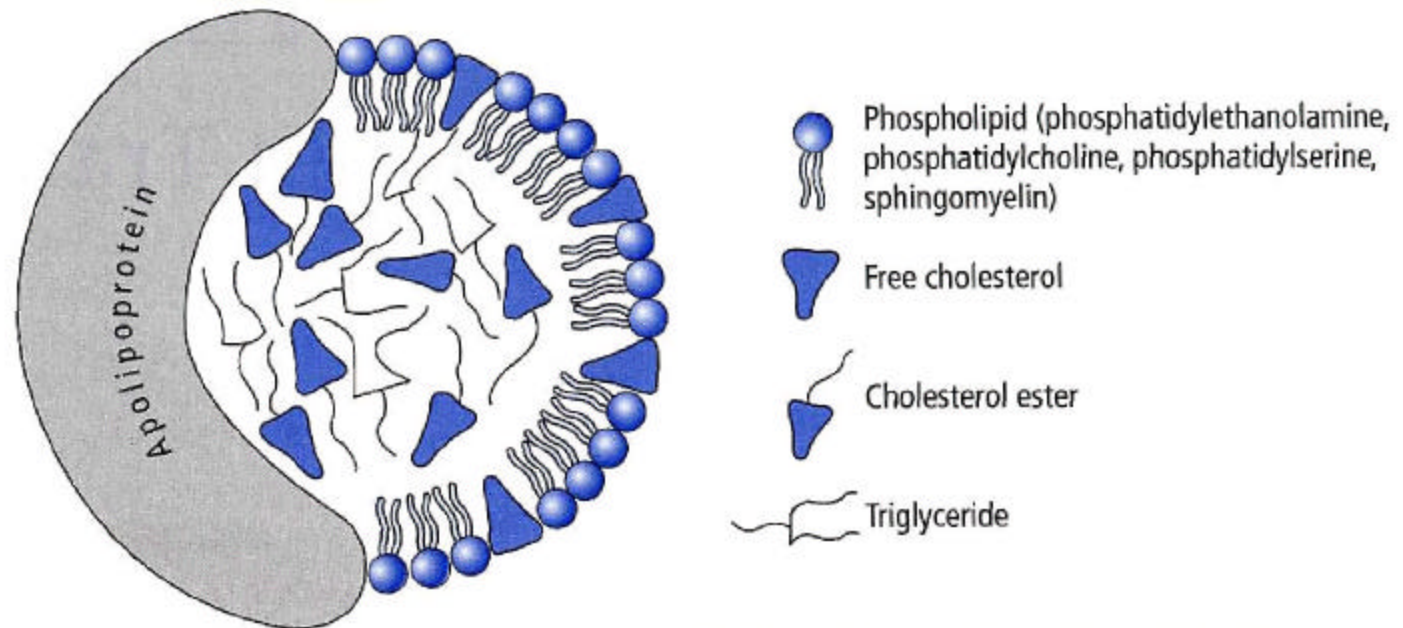
Interorgan transport of cholesterol.



Lipoproteins

FIG. 20.1

General structure of a lipoprotein.



Transport of Dietary Fat to the Liver

Intestinal cells package dietary fat (mostly TG) into chylomicrons

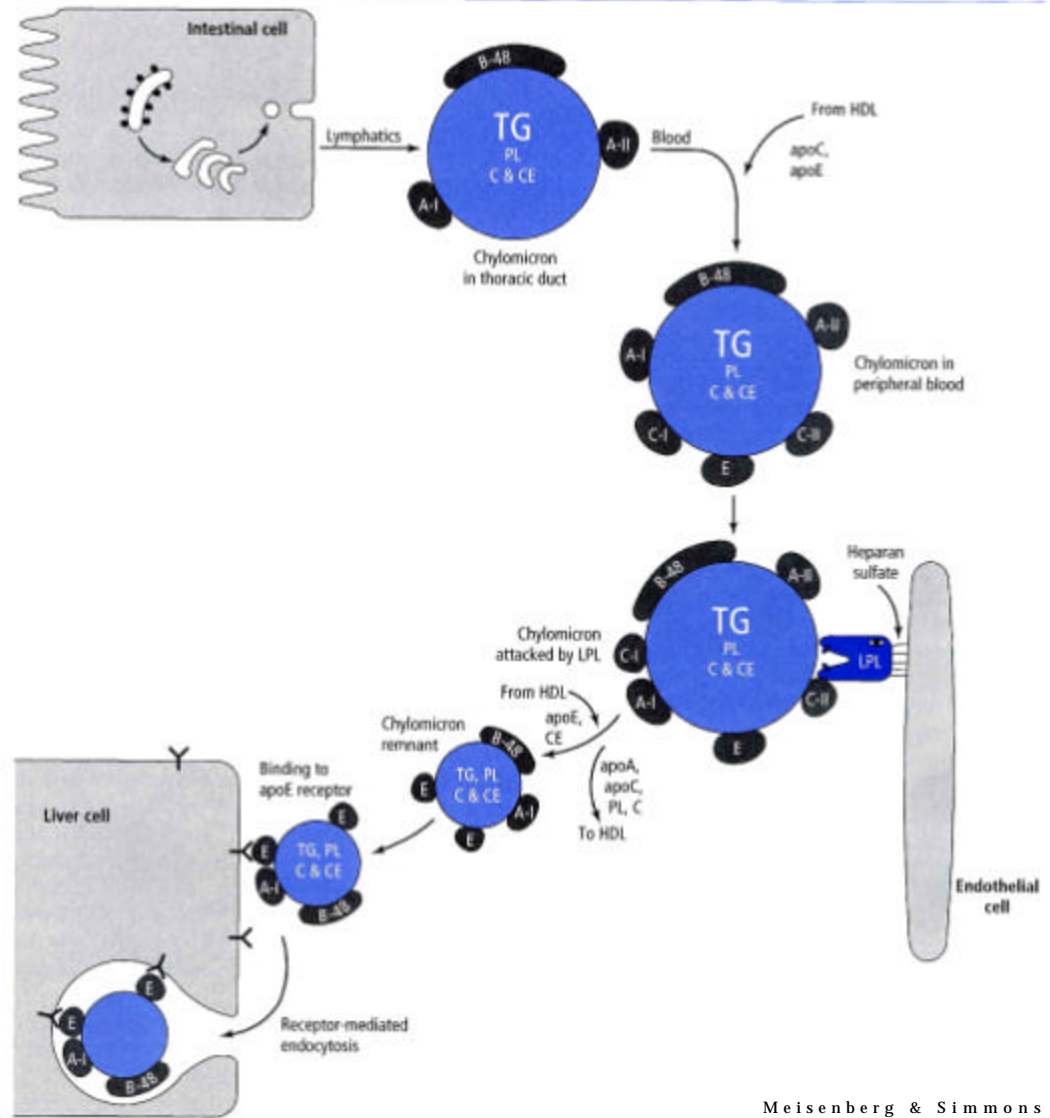
Chylomicrons pick up proteins from HDL

Lipoprotein lipase (LPL) removes TG for use in tissues (Apo-C-II activates LPL)

Chylomicron remnants are taken up by the liver

FIG. 20.3

Metabolism of chylomicrons. TG, Triglyceride; PL, phospholipid; C, free cholesterol; CE, cholesterol ester; LPL, lipoprotein lipase.



Export of Fat from the Liver

TG and cholesterol is exported from the liver as nascent VLDL

VLDL picks up proteins from HDL

Lipoprotein lipase (LPL) removes TG for use in tissues (Apo-C-II activates LPL)

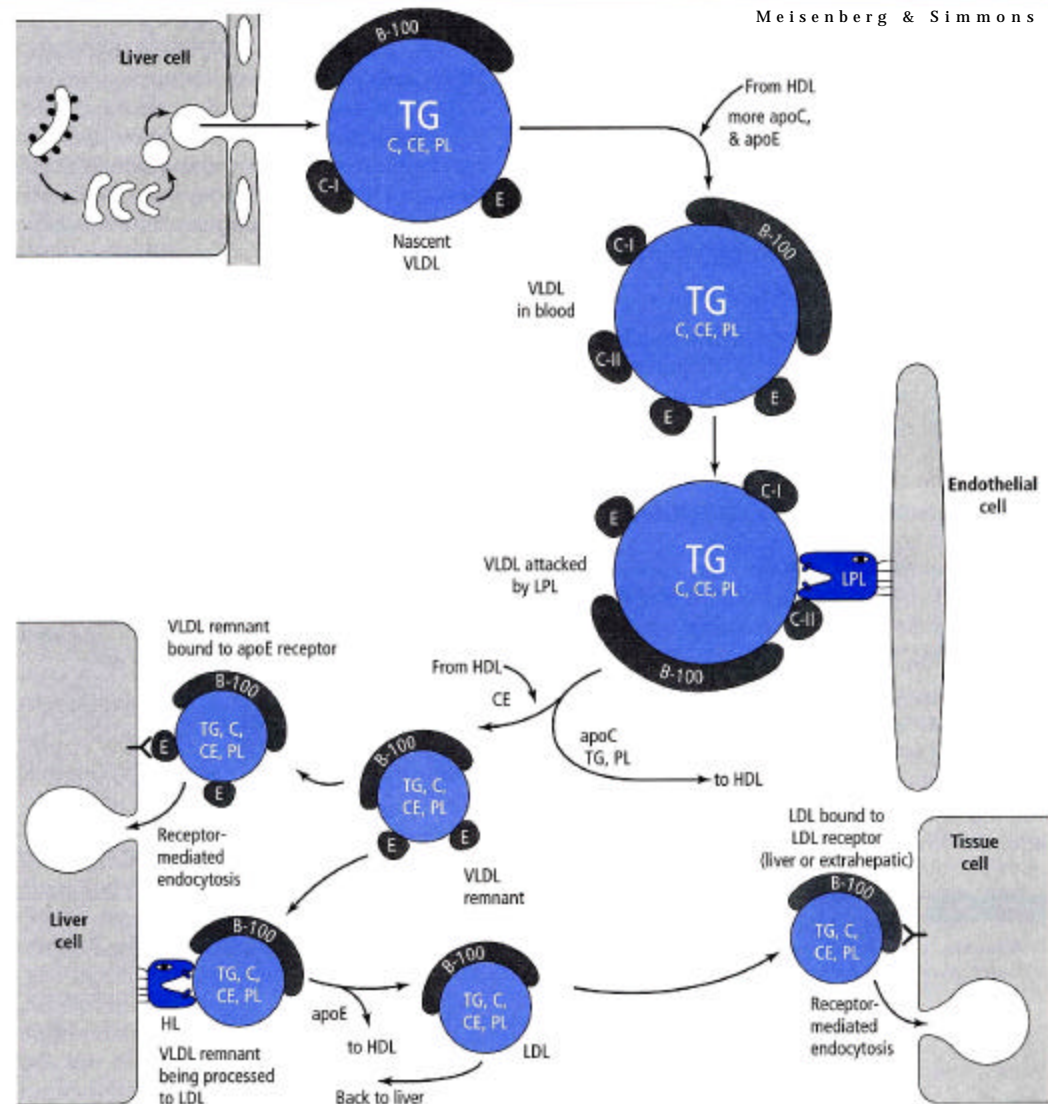
VLDL is transformed to LDL during circulation

LDL delivers cholesterol to tissues by receptor-mediated uptake

FIG. 20.4

Metabolism of VLDL and LDL. TG, Triglyceride; PL, phospholipid; C, free cholesterol; CE, cholesterol esters. LPL, Lipoprotein lipase; HL, hepatic lipase.

Meisenberg & Simmons



Role of HDL in Lipid Metabolism

Nascent HDL is exported from liver and intestinal cells

Free cholesterol is picked up from cells and other lipoproteins, along with other components

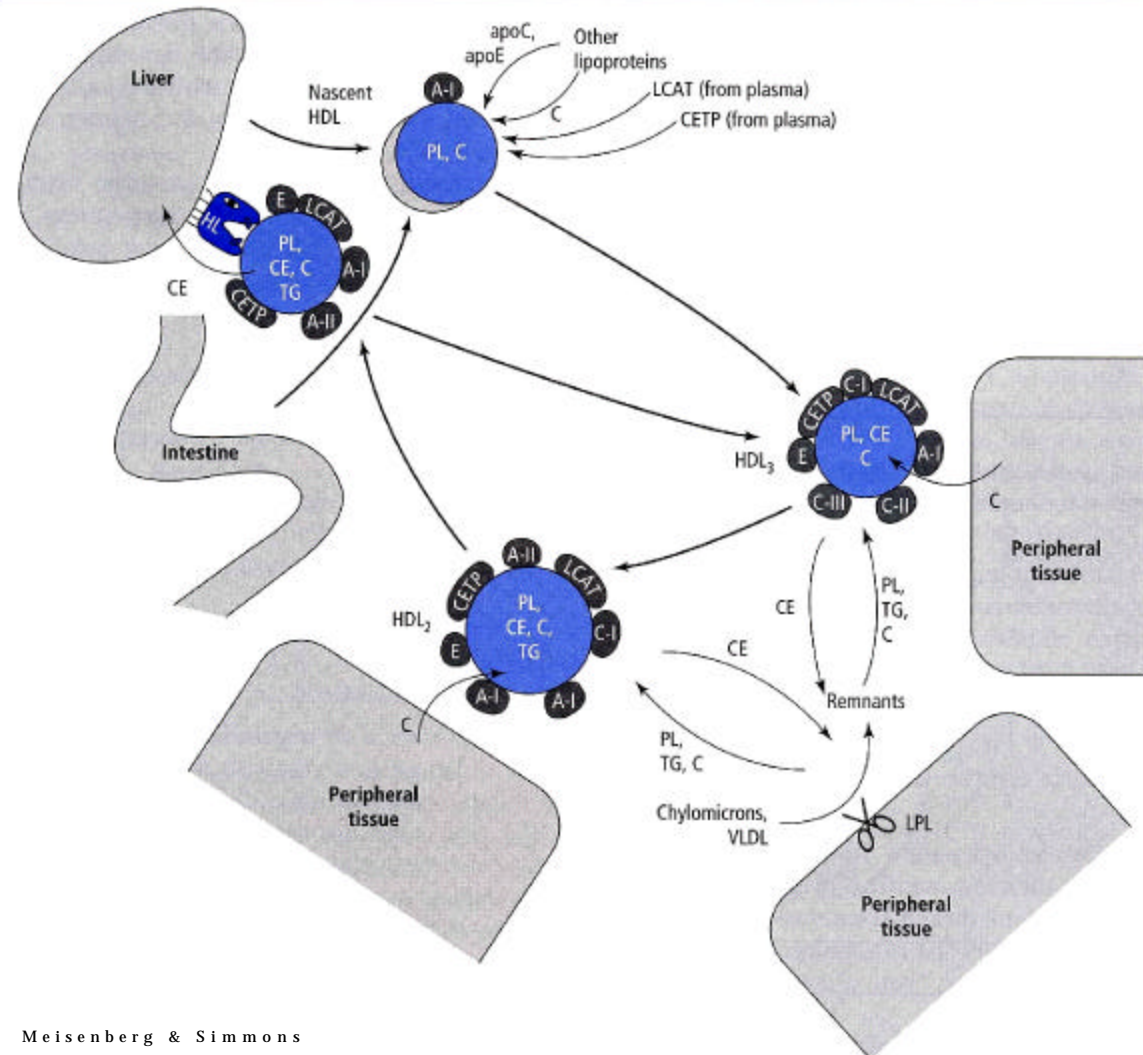
LCAT converts cholesterol to cholesterol esters (CE)

CE is transferred to other lipoproteins

HDL returns cholesterol to the liver

FIG. 20.7

Metabolism of HDL. TG, Triglyceride; PL, phospholipid; C, cholesterol; CE, cholesterol esters; CETP, cholesterol ester transfer protein; LPL, lipoprotein lipase; HL, hepatic lipase. All HDL apolipoproteins can be exchanged with other lipoprotein classes.



Bibliography

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