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.
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.

**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 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.

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

Liver (synthesizes 0.2–0.6 g/day and recycles >95%)
Secondary bile salts are reconjugated

Cholesterol → Bile salts
Gall-bladder

Enterohepatic circulation

Fat digestion
Intestine

Bile salts reabsorbed (12–32 g/day) and returned to liver for recycling > 95% efficiency

Pool of bile salts = 2–4 g (recycles 6–8 times/day)
Bacteria in gut deconjugate and dehydroxylate bile salts

< 5%

Feces (0.2–0.6 g/day)
Solubility of Cholesterol in Bile

### TABLE 19.2

<table>
<thead>
<tr>
<th>Component</th>
<th>Hepatic bile</th>
<th>Bladder bile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>2.5%</td>
<td>10%</td>
</tr>
<tr>
<td>Inorganic salt</td>
<td>0.85%</td>
<td>0.85%</td>
</tr>
<tr>
<td>Bile acids</td>
<td>1.2%</td>
<td>6%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0.06%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Lecithin</td>
<td>0.04%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Bile pigments</td>
<td>0.2%</td>
<td>1.5%</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
<td>5.0–6.0</td>
</tr>
</tbody>
</table>

**FIG. 19.11**

Solubility of cholesterol in the presence of bile acids and phosphatidylycholine ("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 acyl-CoA: cholesterol acyltransferase or by lecithin: cholesterol acyltransferase 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.

Meisenberg & Simmons
Lipoproteins

General structure of a lipoprotein.

- Phospholipid (phosphatidylethanolamine, phosphatidylcholine, phosphatidylycerine, sphingomyelin)
- Free cholesterol
- Cholesterol ester
- Triglyceride
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
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
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
D. B. Marks, A. D. Marks, and C. M. Smith, *Basic Medical Biochemistry: A Clinical Approach*, Williams & Wilkins, 1996
