Learning Objectives

- Classify fats according to their chemical composition and distinguish between saturated and unsaturated, monounsaturated and polyunsaturated, cis and trans, and omega-3, -6, and -9 fatty acids
- Describe the digestion, absorption, transportation, and storage of fat
- Explain the metabolism of fat, including mobilization, transportation, uptake, activation, translocation, and oxidation as well as ketosis and the effect it may have on training

Learning Objectives

- Describe how the body uses fat to fuel exercise
- State fat recommendations for athletes and calculate the amount of fat needed daily
- Identify sources of dietary fat and assess an athlete’s dietary fat intake
- Evaluate dietary supplements related to fat metabolism
Introduction

• Fat
  – Dietary intake
    • There are health risks associated with too much and too little
  – Member of lipids class of compounds
    • Triglycerides (fats and oils)
    • Phospholipids
    • Sterols

Roles of Body Fat

• Lipids: provide energy
• Adipose tissue
  – Fat-storing cells; also secretes hormones
  – Fat stored in fat cells
    • Supplies 60 percent of the body’s ongoing energy needs during rest
  – Fat embedded in muscle
    • Along with glycogen, provides energy to muscle

<table>
<thead>
<tr>
<th>Table 4-1: The Functions of Fats in the Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy stores: fats are the body’s chief form of stored energy.</td>
</tr>
<tr>
<td>Muscle fuel: fats provide much of the energy to fuel muscular work.</td>
</tr>
<tr>
<td>Padding: fat pads inside the body cavity protect the internal organs from shock.</td>
</tr>
<tr>
<td>Insulation: fats insulate against temperature extremes by forming a fatty layer under the skin.</td>
</tr>
<tr>
<td>Cell membranes: fats form the major material of cell membranes.</td>
</tr>
<tr>
<td>Allo materials: fats are converted to other compounds, such as hormones, bile, and vitamin D, as needed.</td>
</tr>
</tbody>
</table>
The Chemist’s View of Lipids

• Triglycerides
  – Predominant form of lipids
  – Three fatty acids attached to a glycerol “backbone”

• Fatty acids
  – Differ in chain length and degree of saturation
  – What is the difference between a saturated fatty acid and an unsaturated fatty acid?

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**TABLE 4-2  The Lipid Family**

<table>
<thead>
<tr>
<th>Triglycerides (fats and oils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Glycerol (1 per triglyceride)</td>
</tr>
<tr>
<td>• Fatty acids (3 per triglyceride)</td>
</tr>
<tr>
<td>- Saturated</td>
</tr>
<tr>
<td>- Monounsaturated</td>
</tr>
<tr>
<td>- Polyunsaturated</td>
</tr>
<tr>
<td>- Omega-6</td>
</tr>
<tr>
<td>- Omega-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phospholipids (such as the lecithins)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sterols (such as cholesterol)</th>
</tr>
</thead>
</table>
The Chemist’s View of Lipids

CAN YOU TELL BY LOOKING?

• Comparison of three fats
  – Lard (from pork): most saturated • hardest
  – Chicken fat: less saturated • somewhat soft
  – Safflower oil: most unsaturated • liquid

• Stability
  – Why are polyunsaturated fatty acids most susceptible to becoming rancid?

The Chemist’s View of Lipids (cont’d.)

• Stability
  – Methods manufacturers protect fat-containing products from rancidity
    1. Seal products airtight and refrigerate
    2. Add antioxidants, e.g., BHA and BHT
    3. Hydrogenate products

The Chemist’s View of Lipids (cont’d.)

• Hydrogenation
  – Advantages: protects against oxidation and alters texture
  – What are the disadvantages?

• Essential fatty acids
  – Linoleic acid: omega-6 fatty acid
  – Linolenic acid: omega-3 fatty acid
The Chemist's View of Lipids (cont’d.)

• Phospholipids: class of lipids
  – Food sources: eggs, soybeans, peanuts, etc.
  – Lecithin and other phospholipids
    • Constituents of cell membranes
    • Emulsifiers in the body
    • Some generate signals in cells

The Chemist's View of Lipids (cont’d.)

• Sterols
  – Large, complex molecules
    • Interconnected rings of carbon
    • Cholesterol, vitamin D, and sex hormones
  – Cholesterol
    • Obtained in foods as well as made by the liver

Digestion of Lipids

Dietary Lipid 95% Triglyceride

Fat Goblets

Mouth - None
Stomach - Gastric Lipase
Small Intestine - Bile Salts, Pancreatic Lipase, Lecithinase

Products: Glycerol, FFA, Mono-, Di-, Glycerides, Cholesterol, Cholesterol Esters (Bile)

Bile Emulsification

Water Soluble Micelles

Intestinal Wall

Portal Venous

Lymphatic

Systemic Circulation

VLDL

Liver

Lipoprotein
The Chemist’s View of Lipids (cont’d.)

• Cholesterol
  – Leaves liver by two routes:
    1. Incorporated into bile, stored in the gallbladder, and delivered to the intestine
    2. Via the bloodstream to all the body’s cells

Health Effects and Recommended Intakes of Fats

• Diet high in saturated fats or trans fats
  – Increased risk of cardiovascular disease
  – Greater-than-average chances of some cancers
  – An increasing waistline often increases blood triglycerides

Health Effects and Recommended Intakes of Fats (cont’d.)

• Fats and heart health
  – High LDL: increased likelihood of fatal heart attack or stroke
    • Promotes cholesterol uptake in the blood vessel walls
  – High HDL: lower disease risk
  – Trans fats: raise LDL and lower HDL
Health Effects and Recommended Intakes of Fats (cont’d.)

• Dietary Guidelines for dietary cholesterol
  – Healthy people: less than 300/day
  – People with or at high risk of heart disease: less than 200 mg/day
• Monosaturated fat (olive oil)
  – May prevent heart disease
• Omega-6 and omega-3 fats
  – Lower total cholesterol and LDL

Fat Oxidation During Exercise

6.6 Fat Recommendations for Athletes

• Total energy (kcal) need
  – Macronutrient balance
    • Higher CHO/protein intake typically means lower fat intake
    • Severe restriction of fat intake not recommended
  – Often expressed as a % of total energy intake
    • 20 to 35% total caloric intake
  – May be expressed on g/kg body weight basis
    • ~1.0 g/kg daily
    • May need to be as high as 3.0 g/kg (ultra-endurance athletes)
**Fat Recommendations for Athletes**

- Adjusting fat intake to achieve energy deficits
  - Reducing body fat may result in improved performance
  - Fat intake is typically reduced since reductions to CHO or protein intakes may be detrimental to performance
  - Athletes may consume a short-term, low fat diet to achieve body composition goals
  - The fat intake of a bodybuilder will vary depending on the training cycle

**Inadequate Fat Intake Can Negatively Affect Training, Performance, and Health**

- Effects of an inadequate fat intake on training, performance, and health
  - Inadequate replenishment of intramuscular fat stores
  - Inability to manufacture sex-related hormones
  - Decline in high-density lipoprotein cholesterol (HDL-C)
  - Inadequate fat-soluble vitamin intakes

**Translating Fat Recommendations to Food Choices**

- Many athletes fail to consume an appropriate amount of fat
- Certain unsaturated fatty acids may help to reduce heart disease risk
- Excess saturated fat intake should be avoided
Summary

- Fat is the most energy-dense nutrient found in food
- The predominant fat in food and in the body is the triglyceride
- Fat absorption, digestion, transportation, and metabolism are slow and complicated
- The main sites of fat storage are adipocytes, liver, and muscle cells
- Fat is the primary energy source at rest and during low-intensity activity

Summary

- Athletes find that their diets tend to be relatively lower in fat than the typical American diet
- Caution should be used when restricting fat because athletes can reduce the fat in their diets too much