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 4-1 The Functions of Fats in the Body

- **Energy stores.** Fats are the body’s chief form of stored energy.
- **Muscle fuel.** Fats provide much of the energy to fuel muscular work.
- **Padding.** Fat pads inside the body cavity protect the internal organs from shock.
- **Insulation.** Fats insulate against temperature extremes by forming a fat layer under the skin.
- **Cell membranes.** Fats form the major material of cell membranes.
- **Raw materials.** Fats are converted to other compounds, such as hormones, bile, and vitamin D, as needed.
<table>
<thead>
<tr>
<th>TABLE 4-2</th>
<th>The Lipid Family</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Triglycerides (fats and oils)</strong></td>
<td></td>
</tr>
<tr>
<td>• Glycerol (1 per triglyceride)</td>
<td></td>
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<tr>
<td>• Fatty acids (3 per triglyceride)</td>
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<tr>
<td>Saturated</td>
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<tr>
<td>Monounsaturated</td>
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<tr>
<td>Polyunsaturated</td>
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<tr>
<td>Omega-6</td>
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<tr>
<td>Omega-3</td>
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<tr>
<td><strong>Phospholipids (such as the lecithins)</strong></td>
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<tr>
<td><strong>Sterols (such as cholesterol)</strong></td>
<td></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?
Glycerol

3 fatty acids of differing lengths

Triglyceride formed from 1 glycerol + 3 fatty acids

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*BHA is butylated hydroxyanisole; BHT is butylated hydroxytoluene.
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
Dietary Lipids

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

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

Fat Drop

Bile

Emulsification

Water Soluble Micelles

Intestinal Wall

Chylomicrons

Liver

Portal
- Glycerol
- Shortchain
- FA 4-6

Lipoprot. VLDL

Systemic Circulation

Dietary Lipid
- 95% Triglyceride
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

- **CHO** = carbohydrate
- **\( \dot{V}O_2 \text{max} \)** = maximum oxygen consumption
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