The Lipids: Triglycerides, Phospholipids and Sterols

Chapter 5
Objectives

5.1 Recognize the chemistry of fatty acids and triglycerides and differences between saturated and unsaturated fats.
  a. Describe the structure of a fatty acid
  b. Describe the triglyceride.
  c. List and describe the three types of fatty acids found in foods.
  d. Explain the structure of the omega-3 and -6 fatty acids.

5.2 Describe the chemistry, food sources, and roles of phospholipids and sterols.

5.3 Summarize fat digestion, absorption, and transport.
  a. Describe the role of the liver in the production of lipoproteins.
  b. Explain the health implications of LDL and HDL and the factors that raise or lower levels of these lipoproteins.

5.4 Outline the major roles of fats in the body, including a discussion of essential fatty acids and the omega fatty acids.
  a. Identify the uses of triglyceride in the body.

5.5 Identify which fats support health and which impair it, including saturated fat, monounsaturated fat, polyunsaturated fat, omega-3 fatty acids and trans-fatty acids.
  a. Name practical suggestions for food selections to replace saturated and trans fats with monounsaturated and polyunsaturated fats.
The Lipid Family

- **Triglycerides (fats and oils)**
  - Predominate in the body (99%) and in foods (95%)
  - Composed of Carbon, Hydrogen and Oxygen
  - 9 kcalories per gram

- **Phospholipids (such as lecithin)**

- **Sterols (such as cholesterol)**
Chemist’s View of Fatty Acids and Triglycerides

**Triglycerides**
1. Composed of glycerol + 3 fatty acids
2. Fatty acids may be 4-24 carbons long
   - Even numbers
   - 18 carbons fatty acids most common
3. Saturated or Unsaturated
   - Monounsaturated or polyunsaturated
4. Omega-3 and Omega-6 fatty acids are of importance in nutrition.
5. Essential Fatty acids include:
   - Omega-3-linolenic
   - Omega-6 linoleic
What is a Fatty Acid?

- Composed of a chain of carbon atoms with hydrogen atoms attached
- Have an acid group at one end and a methyl group at the other end.
- Usually even numbers of carbons

![Molecule diagram showing a fatty acid structure with methyl and acid ends.](image-url)
A Fatty Acid

Stearic acid, an 18-carbon saturated fatty acid.

Stearic acid (simplified structure).
Fatty Acids

Chain Length

- Long-chains are 12 - 24 carbons in length
  - common in meats, fish and vegetable oils
  - 18-carbon fatty acids are abundant in food
- Medium chains are 6 - 10 carbons
  - coconut and palm oils
- Short chains are < 6 carbons
  - dairy products

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Stearic acid
The Number of Double Bonds

Degree of Saturation

- Saturated fatty acid: contains the maximum possible number of hydrogen atoms
- No double bonds

- Stearic acid; 18 carbon saturated fatty acid
The Number of Double Bonds

- **Unsaturated fatty acid:**
  - Has some hydrogen atoms missing and therefore has at least 1 double bond

- **Monounsaturated fatty acid:**
  - Has 1 double bond (missing 2 hydrogen atoms)
  - *Oleic acid* found in olive oil and canola
The Number of Double Bonds

- **Polyunsaturated fatty acid:**
  - has 2 or more double bonds
  - *linoleic acid* has 2
  - *linolenic acid* found in soybean oil has 3

- 18 carbon polyunsaturated fatty acid
  - *linoleic acid*
  - found in corn, safflower, sunflower, and soybean oils

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Stearic acid, an 18-carbon saturated fatty acid

Oleic acid, an 18-carbon monounsaturated fatty acid

Linoleic acid, an 18-carbon polyunsaturated fatty acid
# 18-Carbon Fatty Acids

**Table 5-1 18-Carbon Fatty Acids**

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Carbon Atoms</th>
<th>Number of Double Bonds</th>
<th>Saturation</th>
<th>Common Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stearic acid</td>
<td>18</td>
<td>0</td>
<td>Saturated</td>
<td>Most animal fats</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>18</td>
<td>1</td>
<td>Monounsaturated</td>
<td>Olive and canola oils</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>18</td>
<td>2</td>
<td>Polyunsaturated</td>
<td>Sunflower, safflower, corn, and soybean oils</td>
</tr>
<tr>
<td>Linolenic acid</td>
<td>18</td>
<td>3</td>
<td>Polyunsaturated</td>
<td>Soybean and canola oils, flaxseed, walnuts</td>
</tr>
</tbody>
</table>

NOTE: Chemists use a shorthand notation to describe fatty acids. The first number indicates the number of carbon atoms; the second, the number of the double bonds. For example, the notation for stearic acid is 18:0.

Table 5-1, p. 135
Location of the Double Bonds

- **Omega Number**
- Polyunsaturated acids are identified by the location of their double bond:
  - The *omega* number indicates the position of the 1\textsuperscript{st} double bond in a fatty acid.
  - Counting from the CH\textsubscript{3} group (methyl group)

Linolenic acid, an omega-3 fatty acid
Omega-3 and Omega-6 Fatty Acids Compared

Linolenic acid, an 18-carbon, omega-3 fatty acid

Linoleic acid, an 18-carbon, omega-6 fatty acid
Chemist’s View of Fatty Acids and Triglycerides

- Triglycerides
  - 1 glycerol molecule
  - 3 fatty acids
  - Formed via a condensation reaction
  - Usually contains a mixture of fatty acids (saturated and unsaturated)
Triglyceride Formation
Condensation Reactions

An H atom from glycerol and an OH group from a fatty acid combine to create water, leaving the O on the glycerol and the C at the acid end of each fatty acid to form a bond.

Three fatty acids attached to a glycerol form a triglyceride and yield water. In this example, all three fatty acids are stearic acid, but most often triglycerides contain mixtures of fatty acids (as shown in Figure 5-5).

http://nutrition.jbpub.com/animations/animations.cfm?id=10&debug=0
A Mixed Triglyceride

- Glycerol
  - fatty acids (18-c saturated) stearic acid
  - fatty acids (18-c monounsaturated) oleic
  - fatty acids (18-c polyunsaturated) linoleic
Characteristics of solid fats and oils

Degree of Unsaturation

Firmness

• Unsaturated:
  • Liquid at room temperature
  • Polyunsaturated vegetable oils
  • Vegetable oils make up much of the added fat in the U.S. diet
  • Fast-food chains use them for frying
  • Food manufacturers add them to processed foods
Characteristics of solid fats and oils

Degree of saturation influences firmness at room temperature

- More saturated fats are solid at room temperature
  - Animal fats (fat on the meat and fat in dairy)
  - Tropical Oils – palm oil, palm kernel oil, coconut oil, cocoa butter
  - Softer due to shorter carbon chain
Saturated fatty acids tend to stack together. Consequently, saturated fats tend to be solid (or more firm) at room temperature.

This mixture of saturated and unsaturated fatty acids does not stack neatly because unsaturated fatty acids bend at the double bond(s). Consequently, unsaturated fats tend to be liquid (or less firm) at room temperature.
Fatty Acid Composition of Common Food Fats

**Key:**
- **Red**: Saturated fatty acids
- **Green**: Polyunsaturated, omega-6 fatty acids
- **Blue**: Monounsaturated fatty acids
- **Yellow**: Polyunsaturated, omega-3 fatty acids

**Animal fats and the tropical oils of coconut and palm contain mostly saturated fatty acids.**
- Coconut oil
- Butter
- Beef tallow (beef fat)
- Palm oil
- Lard (pork fat)
- Chicken fat

**Some vegetable oils, such as olive and canola, are rich in monounsaturated fatty acids.**
- Olive oil
- Canola oil
- Peanut oil

**Many vegetable oils are rich in omega-6 polyunsaturated fatty acids.**
- Safflower oil
- Sunflower oil
- Corn oil
- Soybean oil
- Walnut oil
- Cottonseed oil

**Only a few oils provide significant omega-3 polyunsaturated fatty acids.**
- Flaxseed oil
- Fish oil (salmon)

*Salad or cooking type over 70% linoleic acid.*
Characteristics of solid fats and oils

- **Stability**
  - Fat becomes spoiled when exposed to oxygen
  - Particularly polyunsaturated
  - Saturated fats are most resistant to oxidation

To prevent rancidity food companies:
- Use air-tight seals and refrigeration
- Antioxidants are added - BHA, BHT, Vitamin E
- Hydrogenation
Characteristics of solid fats and oils

What is Hydrogenation?
The process of adding hydrogen to unsaturated fatty acids to make the fat more solid and resistant to the chemical change of oxidation
  - Protects against oxidation
  - Alters texture of the food by making liquid vegetable oils more solid
  - Produces trans fatty acids
Double bonds carry a slightly negative charge and readily accept positively charged hydrogen. Most often fat is partially hydrogenated, creating a trans-fatty acid.
Cis-and Trans-Fatty Acids Compared

A *cis*-fatty acid has its hydrogens on the same side of the double bond; *cis* molecules bend into a U-like formation. Most naturally occurring unsaturated fatty acids in foods are *cis*.

A *trans*-fatty acid has its hydrogens on the opposite sides of the double bond; *trans* molecules are more linear. The *trans* form typically occurs in partially hydrogenated foods when hydrogen atoms shift around some double bonds and change the configuration from *cis* to *trans*. 
Characteristics of solid fats and oils

- **Hydrogenated Vegetable Oil**
  - Prevents spoilage of unsaturated fats
  - Hydrogenated oil is used in frying
    - Can be heated to high temperature
  - Easy to handle, easy to spread
  - Once fully hydrogenated, an oil loses both its unsaturated character and health benefits
  - The stick margarines may contain almost 50% of their fat as trans fat
Trans Fatty Acids

- **Trans-Fatty Acids:**
  - Similar in shape to saturated fatty acid
    - Not made by the body
  - Naturally occur in tiny amounts mainly in dairy foods and beef
  - Found in desserts, microwave popcorn, frozen pizza, some margarines and coffee creamer
  - Trans Fatty Acids act like saturated fatty acids in the body.
Phospholipids

- Phospholipids are soluble in both water and fat

- **Cell membranes**
  - Help lipids move across cell membranes,
    - such as vitamins, and hormones

- **Emulsifiers**- keep fat suspended in body fluids

![Diagram of a cell membrane](image)
Lecithin

From glycerol

From phosphate

From 2 fatty acids

The plus charge on the N is balanced by a negative ion—usually chloride.

From choline

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Phospholipids

- Phospholipids in food
  - Found in foods such as eggs, liver, soybeans, wheat germ, peanuts
  - Used in food industry as emulsifiers in foods such as mayonnaise and salad dressings and candy bars
Sterols

- **Sterols in Food:**
  - Most common one is *cholesterol*;
    - Found only in foods of animal origin
    - Meat, eggs, fish and poultry, dairy
  - Plant sterols (phytosterols)
    - Naturally found plants but in very low levels
    - Plant sterols block cholesterol absorption
    - Plant sterols have been added to common foods such as vegetable oil spreads, dairy drinks, snack bars
Sterols

Roles of sterols:
- Cholesterol (component of cell membranes)
  - Made in the liver
- Bile acids
- Sex hormones
- Adrenal hormones
- Vitamin D

Cholesterol can be used as the starting material to make these compounds
Cholic Acid and the Sex Hormones
### Cholesterol Content of Common Foods

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving size (kcalories)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>1 c whole (150 kcal)</td>
</tr>
<tr>
<td>Milk</td>
<td>1 c reduced-fat 2% (121 kcal)</td>
</tr>
<tr>
<td>Yogurt, plain</td>
<td>1 c whole (150 kcal)</td>
</tr>
<tr>
<td>Yogurt, plain</td>
<td>1 c low-fat (155 kcal)</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>1½ oz (170 kcal)</td>
</tr>
<tr>
<td>Cottage cheese</td>
<td>½ c reduced-fat 2% (101 kcal)</td>
</tr>
<tr>
<td>Swiss cheese</td>
<td>1½ oz (140 kcal)</td>
</tr>
<tr>
<td>Ice cream</td>
<td>½ c, 10% fat (133 kcal)</td>
</tr>
<tr>
<td>Butter</td>
<td>1 tsp (36 kcal)</td>
</tr>
<tr>
<td>Shrimp</td>
<td>3 oz boiled (85 kcal)</td>
</tr>
<tr>
<td>Ground beef, lean</td>
<td>3 oz broiled (237 kcal)</td>
</tr>
<tr>
<td>Chicken breast</td>
<td>3 oz roasted (141 kcal)</td>
</tr>
<tr>
<td>Cod</td>
<td>3 oz poached (88 kcal)</td>
</tr>
<tr>
<td>Ham, lean</td>
<td>3 oz roasted (123 kcal)</td>
</tr>
<tr>
<td>Sirloin steak, lean</td>
<td>3 oz broiled (171 kcal)</td>
</tr>
<tr>
<td>Tuna, canned in water</td>
<td>3 oz (99 kcal)</td>
</tr>
<tr>
<td>Bologna, beef</td>
<td>2 slices (144 kcal)</td>
</tr>
<tr>
<td>Egg</td>
<td>1 hard cooked (77 kcal)</td>
</tr>
</tbody>
</table>

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**Key:**
- Milk and milk products
- Meats
- Miscellaneous

**CHOLESTEROL**

Only foods of animal origin contain significant cholesterol. Consequently, grains, vegetables, legumes, and fruits provide virtually no cholesterol.

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Lipid Digestion
In the GI Tract

Mouth and salivary glands
Some hard fats begin to melt as they reach body temperature. The sublingual salivary gland in the base of the tongue secretes lingual lipase. The degree of hydrolysis by lingual lipase is slight for most fats but may be appreciable for milk fats.

Stomach
The stomach’s churning action mixes fat with water and acid. A gastric lipase accesses and hydrolyzes (only a very small amount of) fat.

Small intestine
Cholecystokinin (CCK) signals the gallbladder to release bile (via the common bile duct):

- Fat
- Bile
- Emulsified fat

Pancreatic lipase flows in from the pancreas (via the pancreatic duct):

- Pancreatic (and intestinal) lipase
- Emulsified fat (triglycerides)
- Monoglycerides, glycerol, fatty acids (absorbed)

Large intestine
Some fat and cholesterol, trapped in fiber, exit in feces.
In the stomach, the fat and watery GI juices tend to separate. The enzymes in the GI juices can’t get at the fat.

When fat enters the small intestine, the gallbladder secretes bile. Bile has an affinity for both fat and water, so it can bring the fat into the water.

Bile’s emulsifying action converts large fat globules into small droplets that repel each other.

After emulsification, more fat is exposed to the enzymes, making fat digestion more efficient.
Hydrolysis of a Triglyceride

The triglyceride and two molecules of water are split. The H and OH from water complete the structures of two fatty acids and leave a monoglyceride.

These products may pass into the intestinal cells, but sometimes the monoglyceride is split with another molecule of water to give a third fatty acid and glycerol. Fatty acids, monoglycerides, and glycerol are absorbed into intestinal cells.
Bile’s Routes

Enterohepatic circulation

Reabsorbed and recycled

- In the gallbladder, bile is stored.
- In the liver, bile is made from cholesterol.
- In the small intestine, bile emulsifies fats.
- Bile reabsorbed into the blood
- In the colon, bile that has been trapped by soluble fibers is lost in feces.
Absorption of Fat

1. **Glycerol and small lipids** such as short- and medium-chain fatty acids can move directly into the bloodstream.

2. **Large lipids** such as monoglycerides and long-chain fatty acids combine with bile, forming micelles that are sufficiently water soluble to penetrate the watery solution that bathes the absorptive cells. There the lipid contents of the micelles diffuse into the cells.

Via blood to liver

Via lymph to blood
Large lipids such as monoglycerides and long-chain fatty acids combine with bile, forming micelles that are sufficiently water soluble to penetrate the watery solution that bathes the absorptive cells. There the lipid contents of the micelles diffuse into the cells.
Lipid Absorption

- Directly into bloodstream
  - Glycerol and short- & medium-chain fatty acids
- Lymphatic system
  - Micelles diffuse into intestinal cells
  - Reassembly of triglycerides
  - Packed with proteins – chylomicrons
  - Bypass liver at first
Fat Absorption

http://nutrition.jbpub.com/animations/animations.cfm?id=11&debug=0
A typical lipoprotein contains an interior of triglycerides and cholesterol surrounded by phospholipids. The phospholipids’ fatty acid “tails” point towards the interior, where the lipids are. Proteins near the outer ends of the phospholipids cover the structure. This arrangement of hydrophobic molecules on the inside and hydrophilic molecules on the outside allows lipids to travel through the watery fluids of the blood.
Lipid Transport
Four Main Types of Lipoproteins

Chylomicrons:
- Largest & Least Dense
- Transport diet derived lipid (Trig) from the intestine, through the lymph, to the blood and the rest of the body
- As chylomicrons pass through bloodstream, cells remove lipids from them
- Liver cells remove the remnants from the blood and reassemble them into new triglycerides
Lipid Transport

Very Low Density Lipoprotein (VLDL)
- Made in Liver
- Transport lipids from the liver to the rest of the body
  - Mainly triglyceride (50%)
- As VLDL travel throughout the body, cells remove triglyceride
- As they lose triglyceride, the proportion of cholesterol increases and they become a low density lipoprotein (LDL).
Lipid Transport

Low Density Lipoprotein (LDL)

- Composed primarily of cholesterol
- Circulate throughout the body and release triglyceride, cholesterol and phospholipid to body cells.
- Body cells collect the lipids and use them to make cell membranes, hormones, or store for later use.
- Liver removes LDL from circulation
- Often termed “Bad Cholesterol” because this is the lipoprotein that is linked to heart disease.
Lipid Transport

High Density Lipoprotein (HDL)

- Liver makes HDL to remove cholesterol from the cells and bring it back to the liver for recycling or disposal.
- By decreasing cholesterol in the arteries, HDL lowers heart disease risk; often called the “Good Cholesterol”
Size Comparisons of the Lipoproteins

Notice how large the fat-filled chylomicron is compared with the others and how the others get progressively smaller as their proportion of fat declines and protein increases.

Chylomicrons contain so little protein and so much triglyceride that they are the lowest in density.

Very-low-density lipoproteins (VLDL) are half triglycerides, accounting for their very low density.

Low-density lipoproteins (LDL) are half cholesterol, accounting for their implication in heart disease.

High-density lipoproteins (HDL) are half protein, accounting for their high density.
Lipid Transport

Intestinal cells form chylomicrons from dietary lipids.

Chylomicrons deliver dietary lipids to most of the body's cells.

Liver cells receive small lipids directly from the intestine.

As cells remove lipids from the chylomicron, it becomes a smaller chylomicron remnant.

Liver cells remove chylomicron remnants from the blood.

Liver cells synthesize lipids.

Liver cells form VLDL, which deliver lipids to the body's cells.

Liver cells form HDL, which pick up cholesterol from the body's cells.

LDL deliver lipids to body cells or return to the liver.

HDL deliver cholesterol to the liver for excretion.

As cells remove lipids from the VLDL, it forms a smaller LDL.

Muscle

Fat cell

Key:
- Chylomicron
- LDL
- Chylomicron remnant
- HDL
- VLDL
Health Implications

- High LDL is associated with high risk
- High HDL is associated with low risk

- Factors that lower LDL and or Raise HDL
  - Weight control
  - Mono or polyunsaturated fat instead of saturated
  - Soluble fiber
  - Physical Activity
  - Moderate Alcohol
Lipids in the Body: Roles of Triglycerides

- Provide the cells with energy
  - Virtually unlimited ability to store fat energy
- Adipose tissue stores body fat
  - Secretes hormones (adipokines)
    - Resistin promotes inflammation and insulin resistance
- Other uses of fat in the body
  - Skin insulation
  - Shock absorption
  - Cell membrane material
  - Cell signaling pathways
Essential Fatty Acids

Linoleic acid and Linolenic acid

- Fatty acids that the body cannot make or cannot make in sufficient quantities
- Must be supplied by the diet
- Found in plant and animal sources
- Vegetable Oils, Nuts, Seeds, Fish, Seafood, Meats
- With adequate linoleic acid and linolenic acids, the body can make other members of the lipid family (such as Arachidonic)

The first number indicates the number of carbons and the second, the number of double bonds. Similar reactions occur when the body makes the omega-3 fatty acids EPA and DHA from linolenic acid.
Essential Fatty Acids

Linoleic Acid- Omega 6 fatty acid
- Vegetable oils and meats

Linolenic Acid- Omega-3 fatty acid
- Canola, Soybean, Nuts, Seeds
- Fish Oils-Salmon, Mackerel, Menhaden, Tuna, Sardines, and Lake Trout
- Essential for normal growth and development, especially eyes and brain
- May help with prevention and/or treatment of heart disease, hypertension, arthritis, and cancer

DRI
- Linoleic acid – 5-10% of daily energy
- Linolenic acid – 0.6-1.2% of daily energy
Omega -3 Fatty Acids

- With adequate linolenic acid, the body can make other members of the omega-3 family such as:
  - DHA: docosahexaenoic acid
  - EPA: eicosapentaenoic acid
    - Used to make “eicosanoids” - biologically active compounds
    - Help lower blood pressure
    - Prevent clot formation
    - Protect against irregular heartbeats
    - Reduce inflammation
Essential Fatty Acids

- **Fatty Acid Deficiency**
  - U.S. diets meets essential fatty acid needs
  - Historically, deficiencies developed in children fed fat-free milk or in hospitalized patients fed fat-free formulas
  - Symptoms:
    - Growth retardation
    - Reproductive Failure
    - Skin lesions
    - Kidney Disease
    - Neuro and visual problems
Lipid Metabolism

Storing Fat as Fat:
- Fat is stored as triglyceride in adipose tissue.
- Adipose tissue has an unlimited capacity to store fat.
- Lipoprotein Lipase-An enzyme on the surface of the adipose cell
- Inside the cell the pieces are reassembled into triglyceride for storage or energy use
An Adipose Cell

Newly imported triglycerides first form small droplets at the periphery of the cell, then merge with the large, central globule.

Large central globule of (pure) fat

Cell nucleus

Cytoplasm

As the central globule enlarges, the fat cell membrane expands to accommodate its swollen contents.

Triglycerides can be made from:
Carbohydrate
Protein, and Fat

Adipose tissue. During times of weight gain, excess fat consumed in the diet is stored in the adipose tissue.
Lipid Metabolism

Using Fat for Energy:
- Fat provides 60% of energy needs during rest
- Glycerol and fatty acids are released directly into the bloodstream for cells to use for energy
- 1 pound of fat = 3500 kcal.
- Only the glycerol portion of triglyceride can be converted to glucose for brain, nerve and RBCs
  - the fatty acids cannot be converted to glucose.
Health Effects of Saturated Fats

**Heart Disease**
- Leading cause of death in adults
- High LDL cholesterol increases risk
- Cholesterol based plaque buildup restricts blood flow and raises blood pressure
- **Saturated fats** raise LDL cholesterol levels much more dramatically than food cholesterol and promote blood clotting

**Sources of Saturated fats:**
- Whole milk, cream, butter, cheese
- Fatty cuts of beef and pork
- Coconut, palm and palm kernel oils-candies, pastry, pies, doughnuts, cookies
Health Effects of Saturated Fats

- Desirable blood lipid profile
  - Total cholesterol < 200 mg/dL
  - LDL cholesterol < 100 mg/dL
  - HDL cholesterol ≥ 60 mg/dL
  - Triglycerides < 150 mg/dL
  - Blood lipid profile
Health Effects of Saturated Fats

- Risks from Trans Fats
  - *Trans*-fatty acids in the diet
    - increase LDL cholesterol and decrease HDL cholesterol.
  - Food sources include deep-fried foods using vegetable shortening, cakes, cookies, doughnuts, pastry, crackers, snack chips, margarine
  - Butter versus margarine
    - Soft –liquid or tub
    - *Trans fat* free
    - Liquid vegetable oil as 1st ingredient
    - <2 grams saturated fat

- Food sources of cholesterol include:
  - egg yolks, milk products, meat, poultry and shellfish.
### Butter

**Nutrition Facts**
- **Serving Size**: 1 Tbsp (14g)
- **Servings per container**: about 32
- **Amount per serving**:
  - Calories: 100
  - Calories from Fat: 100
  - %Daily Value:
    - Total Fat: 11g (17%)
    - Saturated Fat: 7g (37%)
    - Trans Fat: 0g
    - Cholesterol: 30mg (10%)
    - Sodium: 95mg (4%)
    - Total Carbohydrate: 0g (0%)
    - Protein: 0g
    - Vitamin A: 8%
    - Vitamin C: Not a significant source
    - Calcium: Not a significant source
    - Iron: Not a significant source

**Ingredients**: Cream, salt.

### Margarine (stick)

**Nutrition Facts**
- **Serving Size**: 1 Tbsp (14g)
- **Servings per container**: about 32
- **Amount per serving**:
  - Calories: 100
  - Calories from Fat: 100
  - %Daily Value:
    - Total Fat: 11g (17%)
    - Saturated Fat: 2g (11%)
    - Trans Fat: 2.5g
    - Polyunsaturated Fat: 3.5g
    - Monounsaturated Fat: 2.5g
    - Cholesterol: 0mg (0%)
    - Sodium: 105mg (4%)
    - Total Carbohydrate: 0g (0%)
    - Protein: 0g
    - Vitamin A: 10%
    - Vitamin C: Not a significant source
    - Calcium: Not a significant source
    - Iron: Not a significant source

**Ingredients**: Liquid soybean oil, partially hydrogenated soybean oil, water, buttermilk, salt, soy lecithin, sodium benzoate (as a preservative), vegetable mono and diglycerides, artificial flavor, vitamin A palmitate, colored with beta carotene (provitamin A).

### Margarine (tub)

**Nutrition Facts**
- **Serving size**: 1 Tbsp (14g)
- **Servings per container**: about 32
- **Amount per serving**:
  - Calories: 100
  - Calories from Fat: 100
  - %Daily Value:
    - Total Fat: 11g (17%)
    - Saturated Fat: 2.5g (13%)
    - Trans Fat: 2.5g
    - Polyunsaturated Fat: 4g
    - Monounsaturated Fat: 2.5g
    - Cholesterol: 0mg (0%)
    - Sodium: 80mg (3%)
    - Total Carbohydrate: 0g (0%)
    - Protein: 0g
    - Vitamin A: 10%
    - Vitamin C: Not a significant source
    - Calcium: Not a significant source
    - Iron: Not a significant source

**Ingredients**: Liquid soybean oil, water, salt, hydrogenated cottonseed oil, vegetable monoglycerides and soy lecithin (emulsifiers), potassium sorbate and sodium benzoate (to preserve freshness), artificial flavor, phosphoric acid (acidulant), colored with beta carotene (source of vitamin A), vitamin A palmitate.

### Margarine (liquid)

**Nutrition Facts**
- **Serving size**: 1 Tbsp (14g)
- **Servings per container**: about 24
- **Amount per serving**:
  - Calories: 70
  - Calories from Fat: 70
  - %Daily Value:
    - Total Fat: 5g (13%)
    - Saturated Fat: 1.5g (7%)
    - Trans Fat: 0g
    - Polyunsaturated Fat: 4.5g
    - Monounsaturated Fat: 2g
    - Cholesterol: 0mg (0%)
    - Sodium: 110mg (8%)
    - Total Carbohydrate: 0g (0%)
    - Protein: 0g
    - Vitamin A: 10%
    - Vitamin C: Not a significant source
    - Calcium: Not a significant source
    - Iron: Not a significant source

**Ingredients**: Liquid soybean oil, water, salt, hydrogenated cottonseed oil, vegetable monoglycerides and soy lecithin (emulsifiers), potassium sorbate and sodium benzoate (to preserve freshness), artificial flavor, phosphoric acid (acidulant), colored with beta carotene (source of vitamin A), vitamin A palmitate.
Health Effects of Saturated Fats

Cancer
- Does not seem to initiate cancer but may promote it once it has arisen
- Colon Cancer- associated with animal fat
- Breast Cancer-association is unclear

Obesity
- Fat 2 x kcal of Protein or Carbohydrate
- High fat diets may exceed energy needs and lead to weight gain
Recommended Intakes of Saturated Fats

- **Recommended Intakes of Fat**
- 20 to 35 percent of kcalories from fat
  - Includes essential fatty acids
- The DRI and the Dietary Guidelines recommend:
  - Limiting 10% of energy intake from saturated fat
  - As little trans fat as possible
  - Focus on healthy oils and limit solid fats in food preparation
## Personal Daily Value for Fat

<table>
<thead>
<tr>
<th>Energy (kcal/day)</th>
<th>20% kCal from Fat</th>
<th>35% kCal from Fat</th>
<th>Fat (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>240</td>
<td>420</td>
<td>27–47</td>
</tr>
<tr>
<td>1400</td>
<td>280</td>
<td>490</td>
<td>31–54</td>
</tr>
<tr>
<td>1600</td>
<td>320</td>
<td>560</td>
<td>36–62</td>
</tr>
<tr>
<td>1800</td>
<td>360</td>
<td>630</td>
<td>40–70</td>
</tr>
<tr>
<td>2000</td>
<td>400</td>
<td>700</td>
<td>44–78</td>
</tr>
<tr>
<td>2200</td>
<td>440</td>
<td>770</td>
<td>49–86</td>
</tr>
<tr>
<td>2400</td>
<td>480</td>
<td>840</td>
<td>53–93</td>
</tr>
<tr>
<td>2600</td>
<td>520</td>
<td>910</td>
<td>58–101</td>
</tr>
<tr>
<td>2800</td>
<td>560</td>
<td>980</td>
<td>62–109</td>
</tr>
<tr>
<td>3000</td>
<td>600</td>
<td>1050</td>
<td>67–117</td>
</tr>
</tbody>
</table>
Health Effects of Mono and Polyunsaturated Fats

- Heart Disease
  - Replacing both saturated and trans fats with monounsaturated and polyunsaturated fats reduces LDL cholesterol and lowers heart disease risk

- Monounsaturated
  - Olive oil, canola oil, peanut oil, avocados

- Polyunsaturated
  - Safflower, sesame, soy, corn, sunflower oils, nuts
Replacing Saturated Fat with Unsaturated Fat

Portion sizes have been adjusted so that each of these foods provides approximately 100 kcalories. Notice that for a similar number of kcalories and grams of fat, the second choices offer less saturated fat and more unsaturated fat.

<table>
<thead>
<tr>
<th>Replace these foods…</th>
<th>Saturated Fat (g)</th>
<th>Unsaturated Fat (g)</th>
<th>Total Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter (1 tbs)</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Bacon (2 slices)</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Potato chips (10 chips)</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Cheese (1 slice)</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Steak (1/2 oz)</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td>18</td>
<td>22</td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>…with these foods</th>
<th>Saturated Fat (g)</th>
<th>Unsaturated Fat (g)</th>
<th>Total Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive oil (1 tbs)</td>
<td>2</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Sunflower seeds (2 tbs)</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Mixed nuts (2 tbs)</td>
<td>1</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Avocado (6 slices)</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Salmon (2 oz)</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Totals</td>
<td>7</td>
<td>35</td>
<td>42</td>
</tr>
</tbody>
</table>
Replacing Saturated with Unsaturated Fat

**SATURATED FATS MEAL**
1 c fresh broccoli topped with 1 tbs butter
1 c mixed baby greens salad with 2 strips bacon (crumbled)
1 oz blue cheese crumble
1 tbs light Italian dressing
4 oz grilled steak

Energy = 600 kcal

**UNSATURATED FATS MEAL**
1 c fresh broccoli sautéed in 1 tbs olive oil
1 c mixed baby greens salad with ½ avocado
2 tbs sunflower seeds
1 tbs light Italian dressing
4 oz grilled salmon

Energy = 600 kcal

To lower saturated fat and raise monounsaturated and polyunsaturated fats...
Health Effects of Lipids

Benefits from Omega-3 Fatty Acids

Reduced risk of heart disease

- Helps prevent blood clots, lowers blood pressure
- Improve blood lipids, suppress inflammation

- Sources include canola, soybean, flaxseed oils, walnuts, fatty fish (mackerel, salmon, sardines)

- Supplements not recommended unless advised by physician
  - Can increase bleeding time, interfere with wound healing, impair immune function
Sources of Omega-3 and Omega-6 Fatty Acids

<table>
<thead>
<tr>
<th>Table 5-4: Sources of Omega-3 and Omega-6 Fatty Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Omega-3</strong></td>
</tr>
<tr>
<td>Linolenic acid</td>
</tr>
<tr>
<td>Oils (canola, flaxseed, soybean, walnut, wheat germ, liquid or soft margarine made from canola or soybean oil)</td>
</tr>
<tr>
<td>Nuts and seeds (flaxseeds, walnuts, soybeans)</td>
</tr>
<tr>
<td>Vegetables (soybeans)</td>
</tr>
<tr>
<td>EPA and DHA</td>
</tr>
<tr>
<td>Human milk</td>
</tr>
<tr>
<td>Fish and seafood:</td>
</tr>
<tr>
<td>&gt;500 mg per 3.5 oz serving: European seabass (bronzini), herring (Atlantic and Pacific), mackerel, oyster (Pacific wild), salmon (wild and farmed), sardines, toothfish (includes Chinian seabass), trout (wild and farmed)</td>
</tr>
<tr>
<td>150–500 mg per 3.5 oz serving: black bass, catfish (wild and farmed), clam, cod (Atlantic), crab (Alaskan king), croakers, flounder, haddock, hake, halibut, oyster (eastern and farmed), perch, scallop, shrimp (mixed varieties), sole, swordfish, tilapia (farmed)</td>
</tr>
<tr>
<td>&lt;150 mg per 3.5 oz serving: cod (Pacific), grouper, lobster, mahimahi, monkfish, red snapper, skate, triggerfish, tuna, wahoo</td>
</tr>
<tr>
<td><strong>Omega-6</strong></td>
</tr>
<tr>
<td>Linoleic acid</td>
</tr>
<tr>
<td>Seeds, nuts, vegetable oils (corn, cottonseed, safflower, sesame, soybean, sunflower), poultry fat</td>
</tr>
</tbody>
</table>

Reading a Fish Oil Label

Notice that this supplement offers 1000 mg of fish oil concentrate per capsule, but the oils offering the most health benefits are EPA and DHA. That information is in the Supplement Facts panel on the back.

Notice that one capsule of this supplement offers 180 mg of EPA and 120 mg of DHA, for a total of 300 mg of omega-3 oils—not 1000 mg. The recommended intake for omega-3 fatty acids is 500 mg per day. For heart health, consumers may need more, perhaps 2 to 4 grams (2000 to 4000 mg) per day.
# Major Sources of Lipids

## TABLE H5-1  Major Sources of Various Fatty Acids

<table>
<thead>
<tr>
<th>Healthful Fatty Acids</th>
<th>Omega-6 Polyunsaturated</th>
<th>Omega-3 Polyunsaturated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monounsaturated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>Margarine (nonhydrogenated)</td>
<td>Fatty fish (herring, mackerel, salmon, tuna)</td>
</tr>
<tr>
<td>Oils (canola, olive, peanut, sesame)</td>
<td>Oils (corn, cottonseed, safflower, soybean)</td>
<td>Flaxseed</td>
</tr>
<tr>
<td>Nuts (almonds, cashews, filberts, hazelnuts, macadamia nuts, peanuts, pecans, pistachios)</td>
<td>Nuts (pine nuts, walnuts)</td>
<td>Nuts (walnuts)</td>
</tr>
<tr>
<td>Olives</td>
<td>Mayonnaise</td>
<td></td>
</tr>
<tr>
<td>Peanut butter</td>
<td>Salad dressing</td>
<td></td>
</tr>
<tr>
<td>Seeds (sesame)</td>
<td>Seeds (pumpkin, sunflower)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harmful Fatty Acids</th>
<th>Trans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated</td>
<td></td>
</tr>
<tr>
<td>Bacon</td>
<td>Fried foods (hydrogenated shortening)</td>
</tr>
<tr>
<td>Butter</td>
<td>Margarine (hydrogenated or partially hydrogenated)</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Nondairy creamers</td>
</tr>
<tr>
<td>Coconut</td>
<td>Many fast foods</td>
</tr>
<tr>
<td>Cream cheese</td>
<td>Shortening</td>
</tr>
<tr>
<td>Cream, half-and-half</td>
<td>Commercial baked goods (including doughnuts, cakes, cookies)</td>
</tr>
<tr>
<td>Lard</td>
<td>Many snack foods (including microwave popcorn, chips, crackers)</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
</tr>
<tr>
<td>Milk and milk products (whole)</td>
<td></td>
</tr>
<tr>
<td>Oils (coconut, palm, palm kernel)</td>
<td></td>
</tr>
<tr>
<td>Shortening</td>
<td></td>
</tr>
<tr>
<td>Sour cream</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Keep in mind that foods contain a mixture of fatty acids.
From Guidelines to Groceries

- Choose lean cuts of meat
- Have 2 servings of fish per week
- Choose fat-free and low-fat milks and milk products
- Vegetables, fruits, and grains
  - Lowers consumption of various fats in the diet
- Invisible fat
  - Fried and baked goods
- Choose wisely
  - Unprocessed foods
Pork chop with fat (340 kcal, 19 g fat, 7 g saturated fat).

Potato with 1 tbs butter and 1 tbs sour cream (350 kcal, 14 g fat, 10 g saturated fat).

Whole milk, 1 c (150 kcal, 8 g fat, 5 g saturated fat).

Pork chop with fat trimmed off (230 kcal, 9 g fat, 3 g saturated fat).

Plain potato (200 kcal, <1 g fat, 0 g saturated fat).

Fat-free milk, 1 c (90 kcal, <1 g fat, <1 g saturated fat).

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Fat in Ground Meats

Higher in fat:
- Regular ground beef: 300 cal/3 oz, 4 1/2 tsp fat
- Ground chuck: 230 cal/3 oz, 3 tsp fat

Commercial ground turkey (with skin ground in):
- 195 cal/3 oz, 2 1/4 tsp fat

Lower in fat:
- Ground round (trimmed, no fat added): 180 cal/3 oz, 1 1/2 tsp fat
Fast Food: Breakfast/Pizza Choices

**Higher in fat**

- **BREAKFAST CHOICES**
  - 2 bacon, cheese, and egg biscuits, hash browns
  - Total calories: 1,190
  - % fat Daily Value: 108%
  - 70 g fat

- **Lower in fat**
  - 2 English muffins, jelly, 1 tsp margarine, orange juice
  - Total calories: 420
  - % fat Daily Value: 9%
  - 6 g fat

**PIZZA CHOICES**

- 2 slices of pepperoni, sausage, and extra-cheese pizza
  - Total calories: 620
  - % fat Daily Value: 55%
  - 36 g fat

- 2 slices of mushroom, onion, green pepper, and cheese pizza
  - Total calories: 400
  - % fat Daily Value: 26%
  - 17 g fat

Note: Fat Daily Value based on a 2,000-calorie diet.

Other types of breakfast sandwiches may or may not be lower in fat. Ask the manager about the ingredients.

To reduce fat, ask for half the normal amount of mozzarella cheese; sprinkle the pizza with a tablespoon of parmesan cheese for flavor.
Fast Food: Taco/Burger Choices

<table>
<thead>
<tr>
<th>Higher in fat</th>
<th>Lower in fat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TACO CHOICES</strong></td>
<td><strong>SANDWICH CHOICES</strong></td>
</tr>
<tr>
<td>2 regular beef tacos, cheese nachos</td>
<td>2 bean burritos, tomato salsa</td>
</tr>
<tr>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>50 g fat</td>
<td>25 g fat</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>77%</td>
<td>38%</td>
</tr>
</tbody>
</table>

Look for taco places that serve reduced-fat cheeses, fat-free sour cream, and baked taco shells.

Some sandwich shops feature low-fat submarine sandwiches, but to keep fat grams low, ask them to hold the oil and mayonnaise.

- Double big bacon cheeseburger on a bun, ice cream shake, fries
- 12-inch turkey submarine sandwich on whole-wheat roll, fat-free milk, a pickle
Counting College Calories

- Krispy Creme glazed doughnut: 200 Kcal, 12 g fat
- Starbucks Grande Frappuccino: 270 Kcal, 4 g fat
- McDonald’s Big Mac: 530 Kcal, 33 g fat
- Super size fries: 610 Kcal, 29 g fat
- Jack in Box taco: 170 Kcal, 9 g fat
- Subway steak and cheese: 412 Kcal, 18 g fat
- 2 large pieces of Domino's pizza pepperoni: 614 kcal, 24 g fat
The Mediterranean Diet

- Traditionally
  - Low in saturated fat
  - Very low in trans fat
  - Rich in unsaturated fat
  - Rich in complex carbohydrate and fiber
  - Rich in nutrients and phytochemicals
- Benefits for heart disease risk
Mediterranean Diet Plan

Mediterranean Diet Pyramid
A contemporary approach to delicious, healthy eating

- Meats and sweets
  - Less often (no more than a few times a month)
- Wine
- Drink water
- Fish and seafood
  - Offers at least two times per week
- Fruits, vegetables, grains (mostly whole), olive oil, beans, nuts, legumes, and seeds, herbs, and spices
  - Base every meal on these foods
- Be physically active
- Enjoy meals with others

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Calculate Personal Daily Value for Fat

1800 total kcal X 0.30 from fat = 540 kcal

\[
\frac{540 \text{ fat kcal}}{9 \text{ kcal per gram}} = 60 \text{ g fat}
\]

<table>
<thead>
<tr>
<th>kcal/day</th>
<th>30% from fat</th>
<th>fat g/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>450</td>
<td>50</td>
</tr>
<tr>
<td>1800</td>
<td>540</td>
<td>60</td>
</tr>
<tr>
<td>2000</td>
<td>600</td>
<td>65</td>
</tr>
<tr>
<td>2200</td>
<td>660</td>
<td>73</td>
</tr>
<tr>
<td>2400</td>
<td>720</td>
<td>80</td>
</tr>
<tr>
<td>2800</td>
<td>840</td>
<td>93</td>
</tr>
</tbody>
</table>
Fat Replacers

Olestra:

Artificial fat.
Sucrose molecule with 6-8 fatty acids attached
Digestive enzymes are unable to break bonds.
Passes through undigested.
Looks, feels, tastes like fat
High heat stable-fry, cook, bake
Provides 0 kcal.
Used in snack foods, chips, crackers
May cause digestive distress: cramps, bloating, gas, diarrhea, fecal urgency, and anal leakage
Binds with fat soluble vitamins (A, D, E, K)
End of Chapter 5