The Lipids: Triglycerides, Phospholipids and Sterols

Chapter 5

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)**

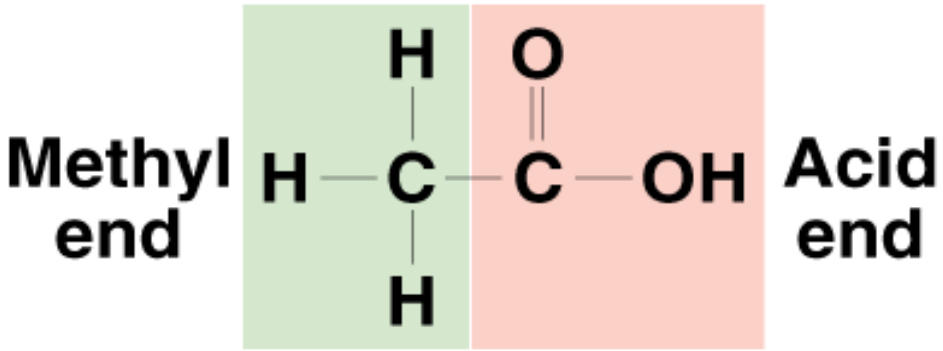
Chemist's View of Fatty Acids and Triglycerides

Triglycerides

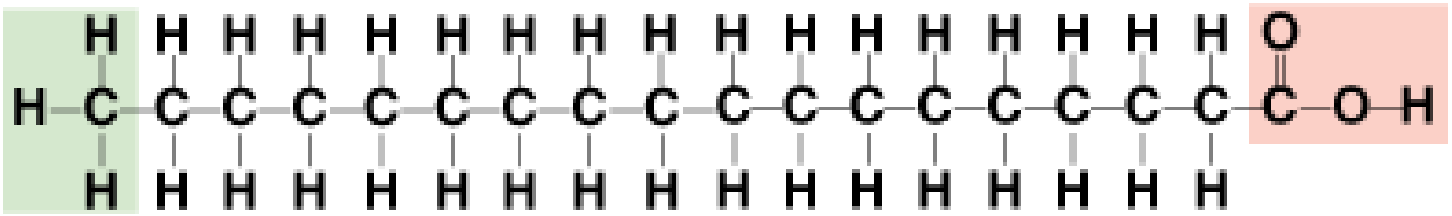
1. Composed of glycerol + 3 fatty acids
2. Fatty acids may be 4-24 carbons long
   - Even numbers
   - 18 carbons fatty acids most common
3. Saturated or Unsaturated
   - monounsaturated or polyunsaturated
4. Omega-3 and Omega-6 fatty acids are of importance in nutrition.
5. Essential Fatty acids include: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

What is a Fatty Acid?

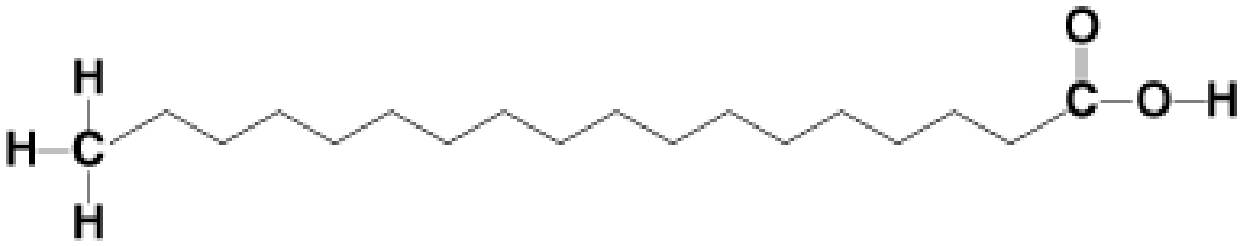
- Composed of a chain of carbon atoms with hydrogen atoms attached
- Have an acid group at one end and a methyl group at the other end.
- Usually even numbers of carbons



A Fatty Acid

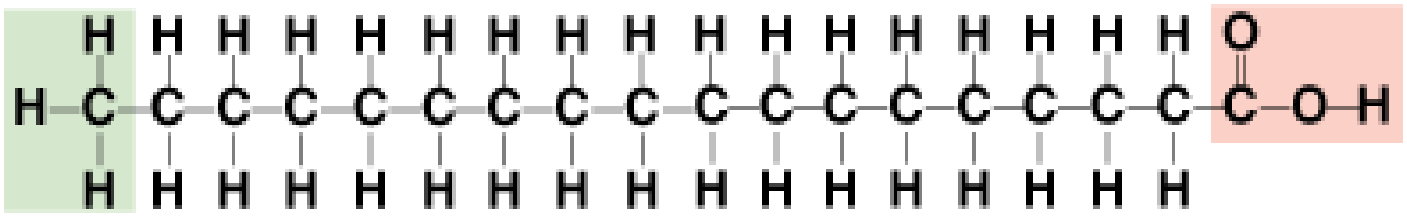


Stearic acid, an 18- carbon saturated fatty acid.



Stearic acid (simplified structure).

Fatty Acids



Stearic acid

Chain Length

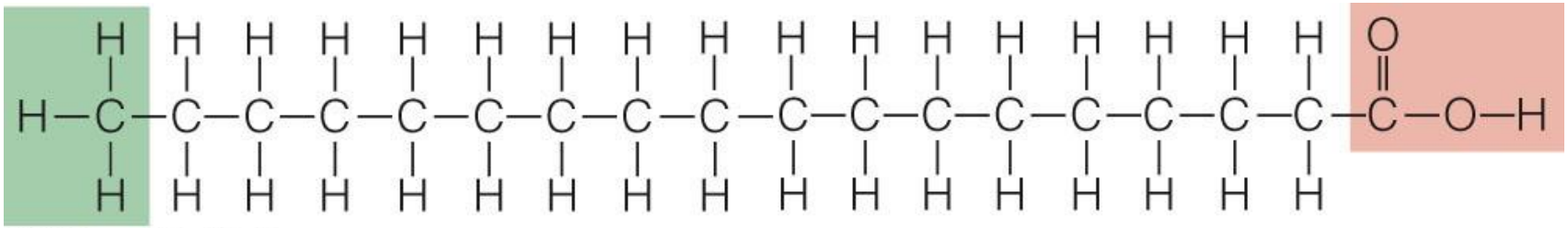
- Long-chains are 12 - 24 carbons in length
  - common in meats, fish and vegetable oils
  - 18-carbon fatty acids are abundant in food
- Medium chains are 6 - 10 carbons
  - coconut and palm oils
- Short chains are < 6 carbons
  - dairy products

The Number of Double Bonds

Degree of Saturation

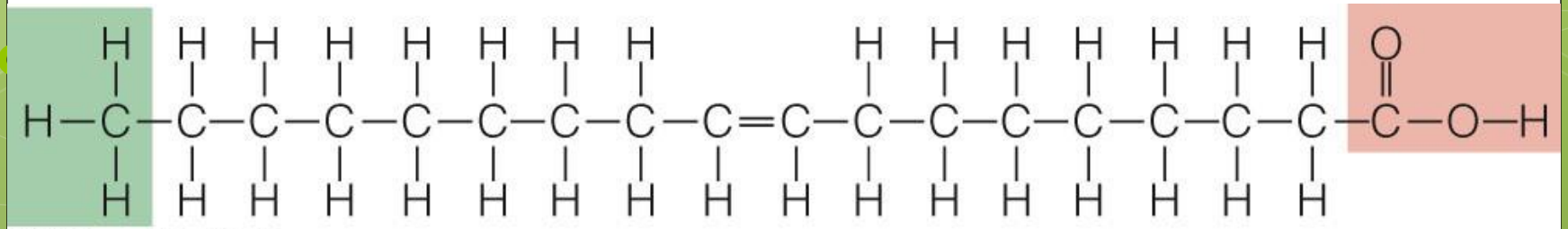
- Saturated fatty acid: contains the maximum possible number of hydrogen atoms
- No double bonds

- Stearic acid; 18 carbon saturated fatty acid



The Number of Double Bonds

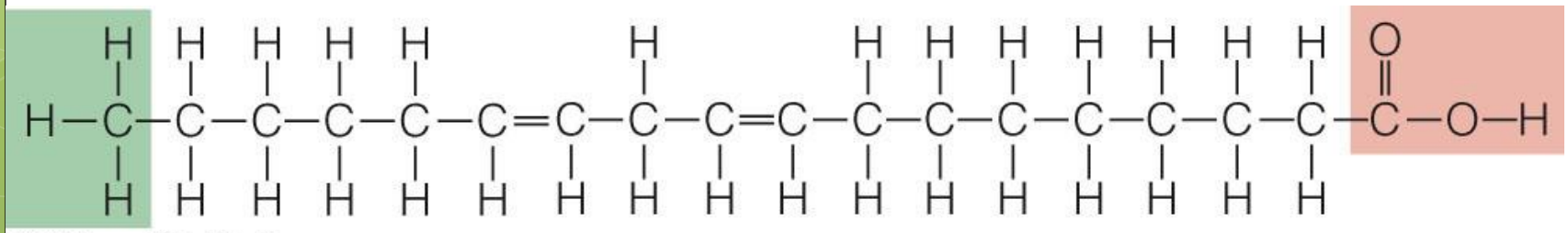
- **Unsaturated fatty acid:**
  - Has some hydrogen atoms missing and therefore has at least 1 double bond
- **Monounsaturated fatty acid:**
  - has 1 double bond (missing 2 hydrogen atoms)
  - *oleic acid found in olive oil and canola*

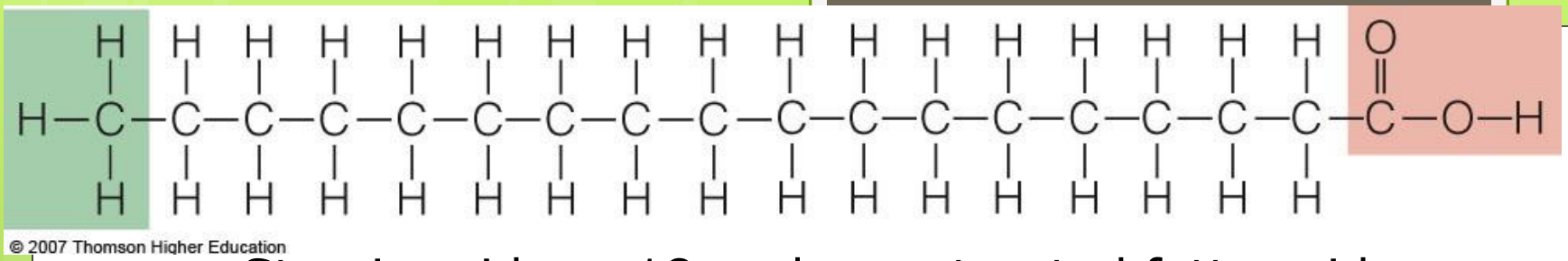


The Number of Double Bonds

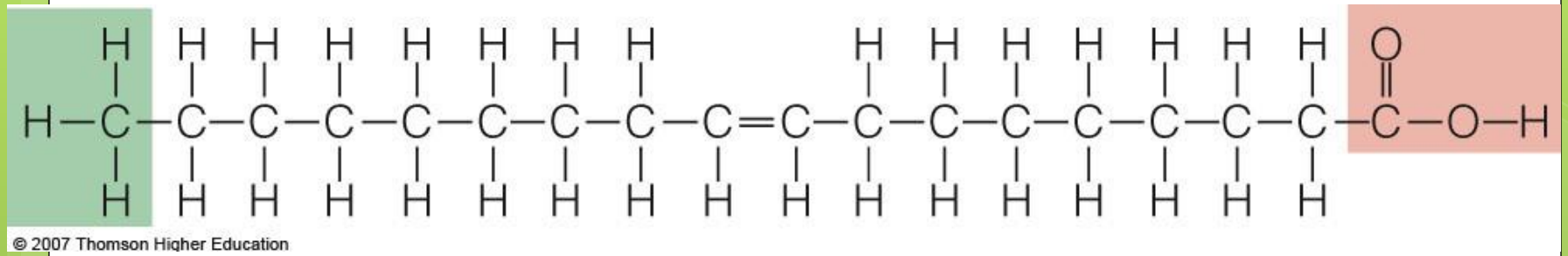
- **Polyunsaturated fatty acid:**
  - has 2 or more double bonds
  - *linoleic acid has 2*
  - *linolenic acid found in soybean oil has 3*

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

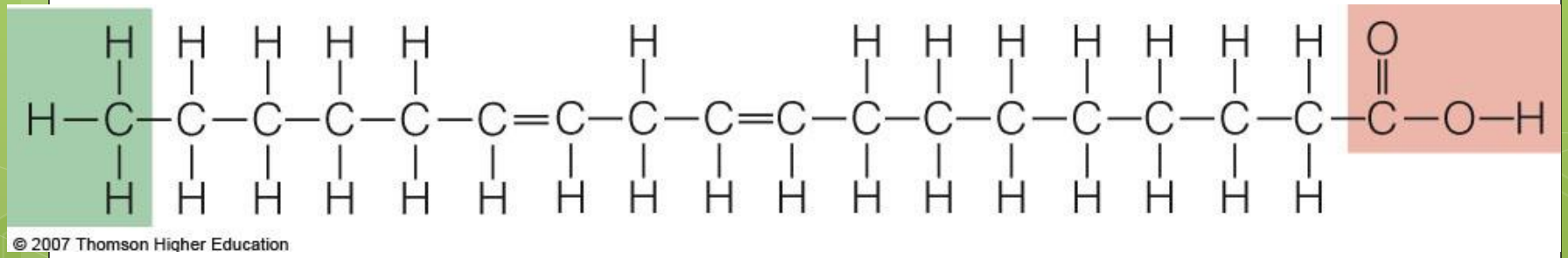




Stearic acid, an 18-carbon saturated fatty acid



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

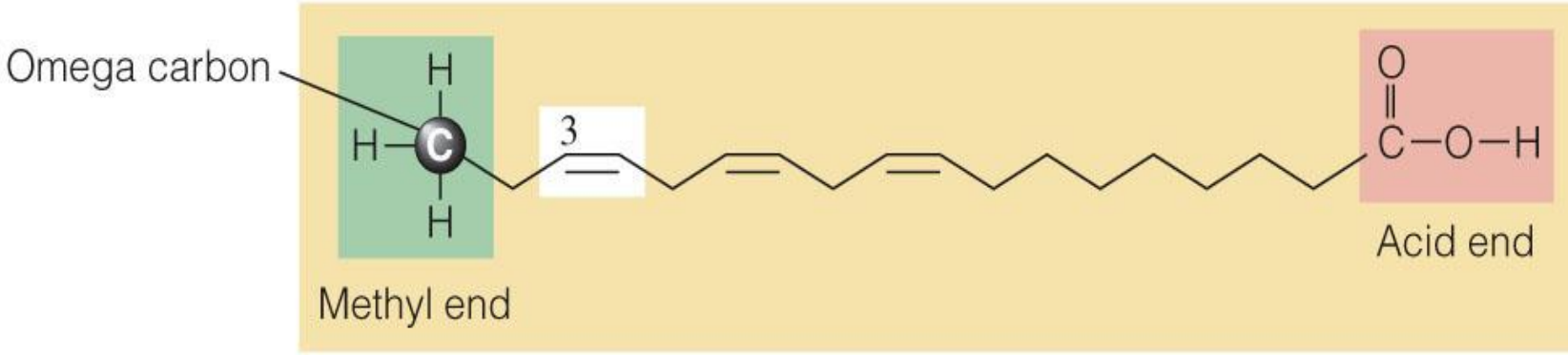
Name	Number of Carbon Atoms	Number of Double Bonds	Saturation	Common Food Sources
Stearic acid	18	0	Saturated	Most animal fats
Oleic acid	18	1	Monounsaturated	Olive and canola oils
Linoleic acid	18	2	Polyunsaturated	Sunflower, safflower, corn, and soybean oils
Linolenic acid	18	3	Polyunsaturated	Soybean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

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.

Location of the Double Bonds

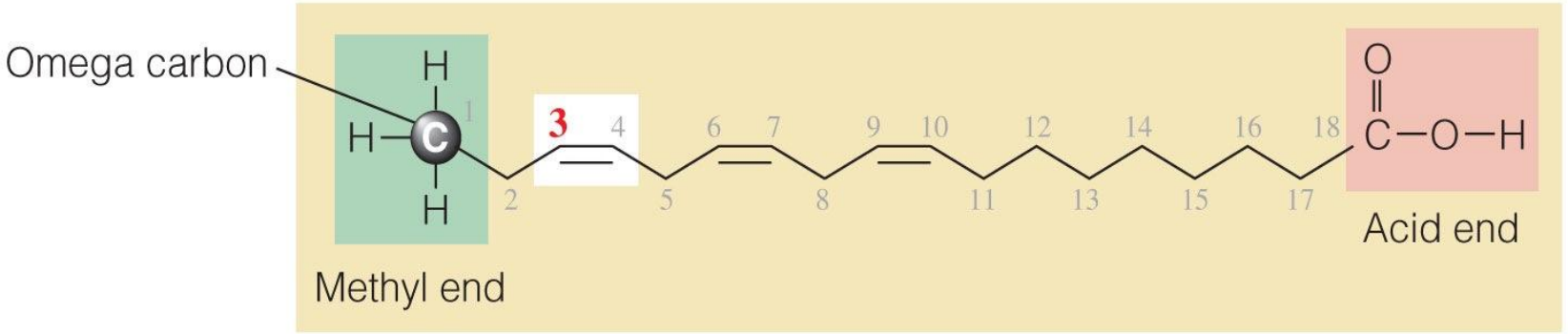
- **Omega Number**
- Polyunsaturated acids are identified by the location of their double bond:
  - The *omega* number indicates the position of the 1st double bond in a fatty acid
  - Counting from the CH_3 group (methyl group)

Linolenic acid, an omega-3 fatty acid

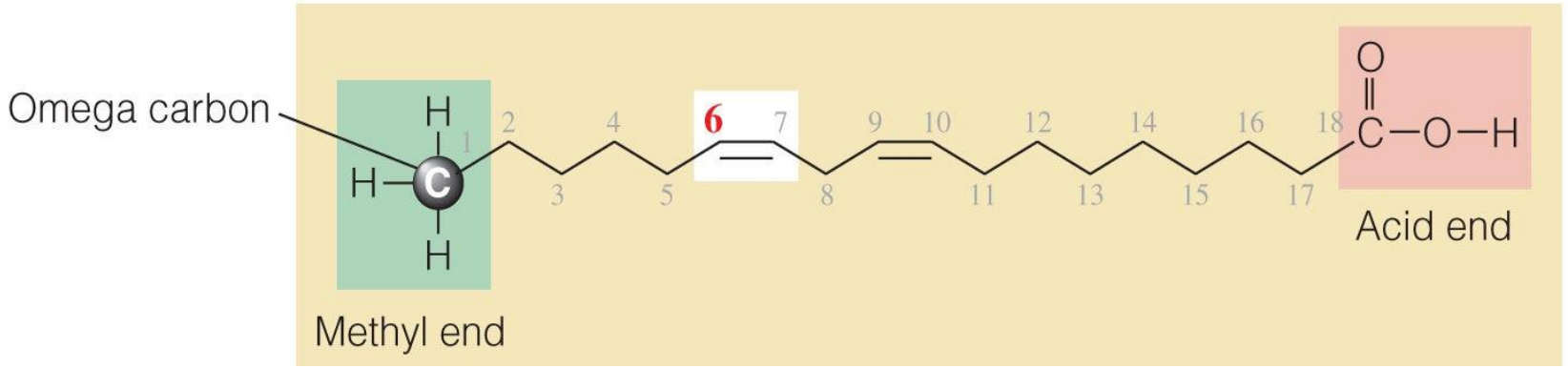


Omega-3 and Omega-6 Fatty Acids Compared

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

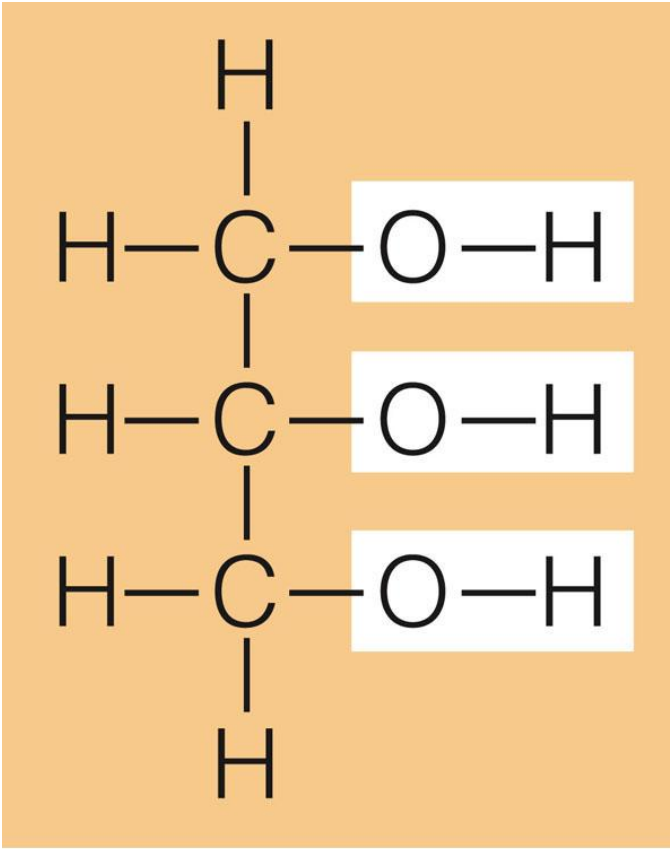


Linoleic acid, an 18-carbon, omega-6 fatty acid



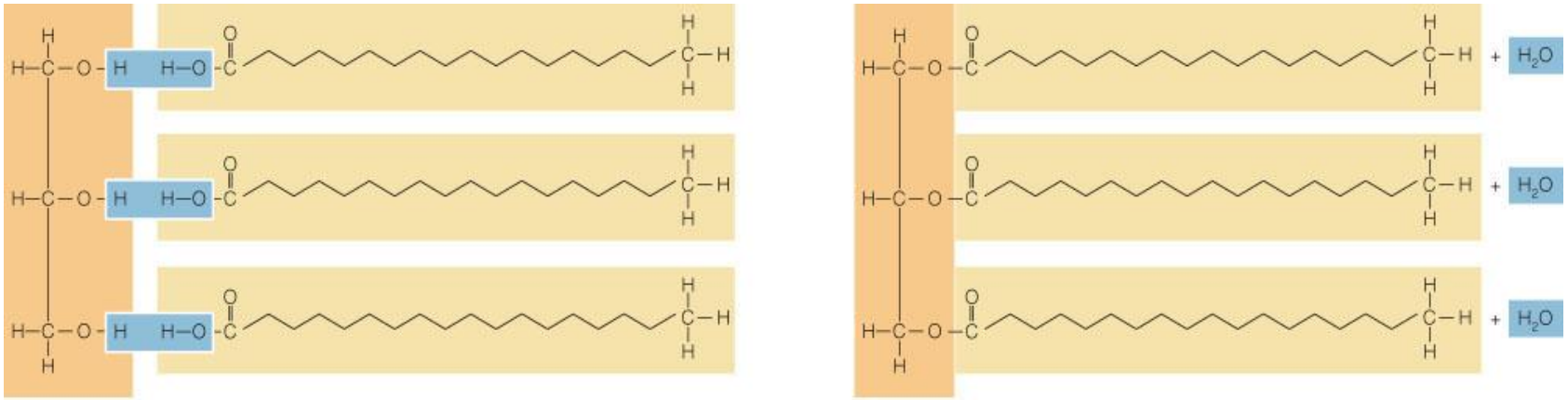
Chemist's View of Fatty Acids and Triglycerides

- 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



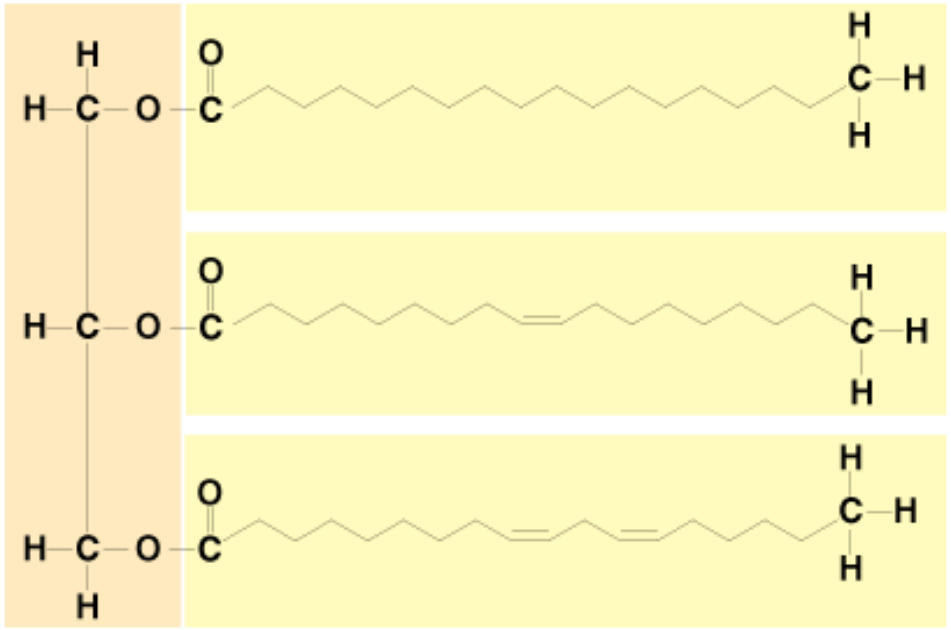
Glycerol + 3 fatty acids → Triglyceride + 3 water molecules

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

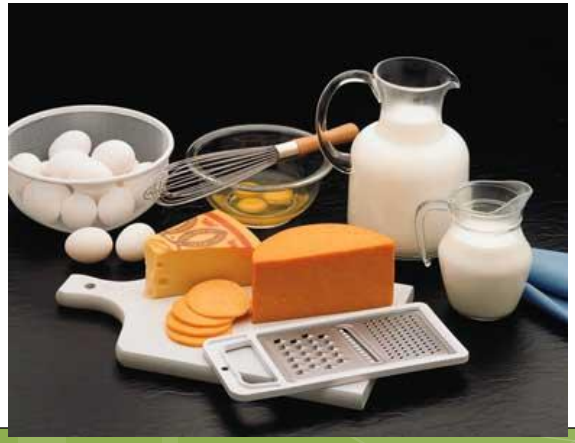
Firmness

- **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

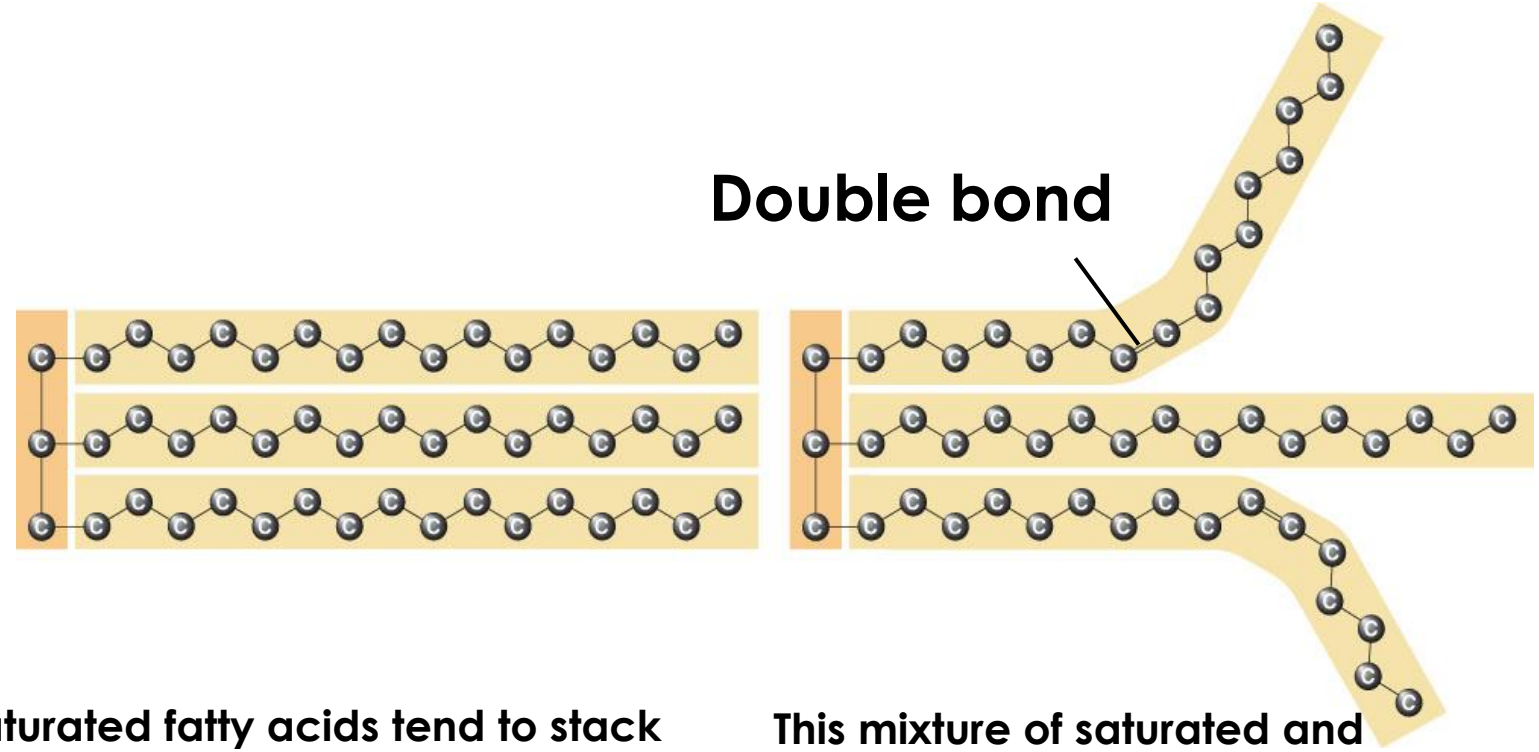
Characteristics of solid fats and oils

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 and Unsaturated Compared

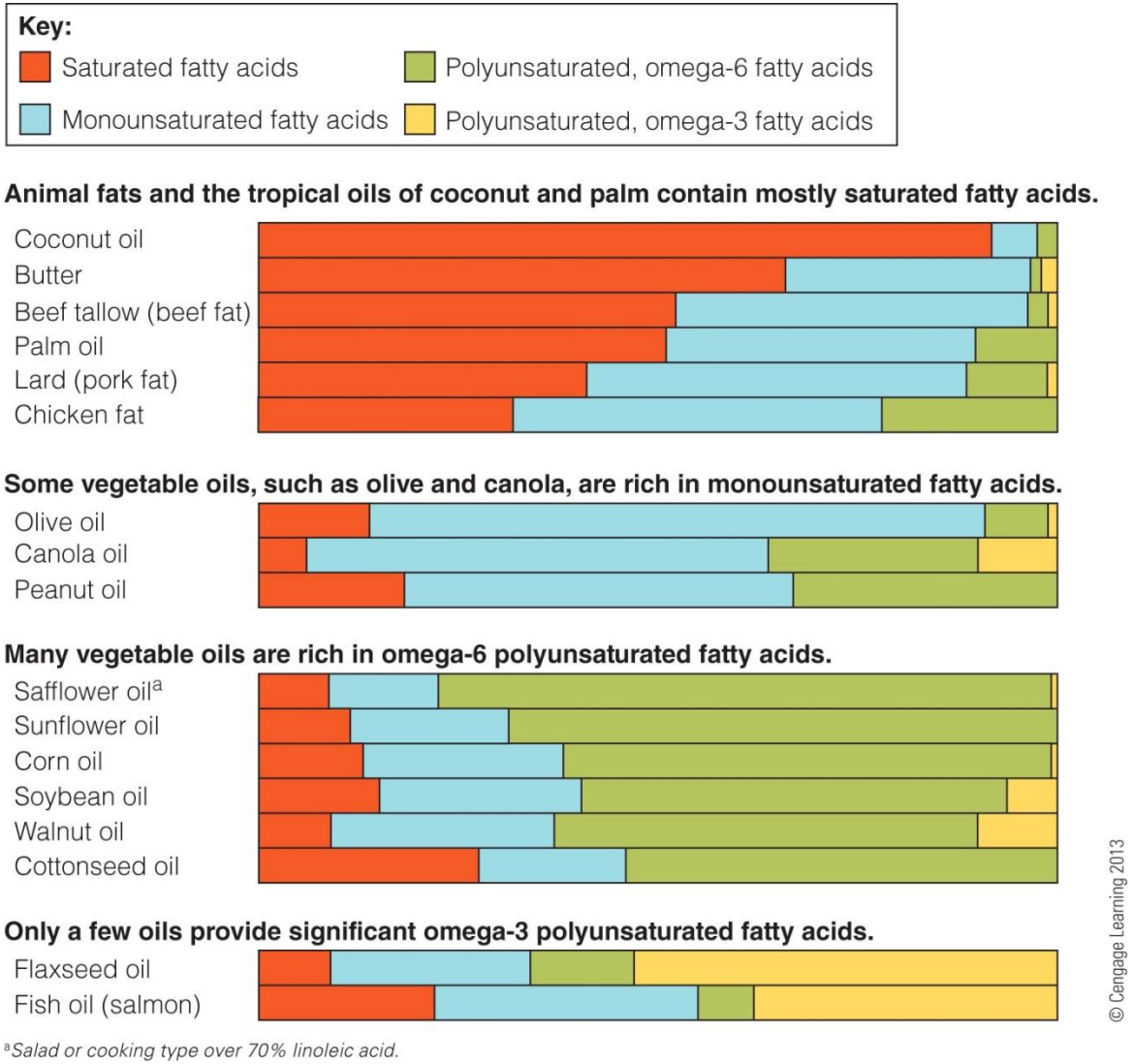


Saturated fatty acids tend to stack together. Consequently, saturated fats tend to be solid (or more firm) at room temperature.

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.

Fig. 5-4, p. 133

Fatty Acid Composition of Common Food Fats



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

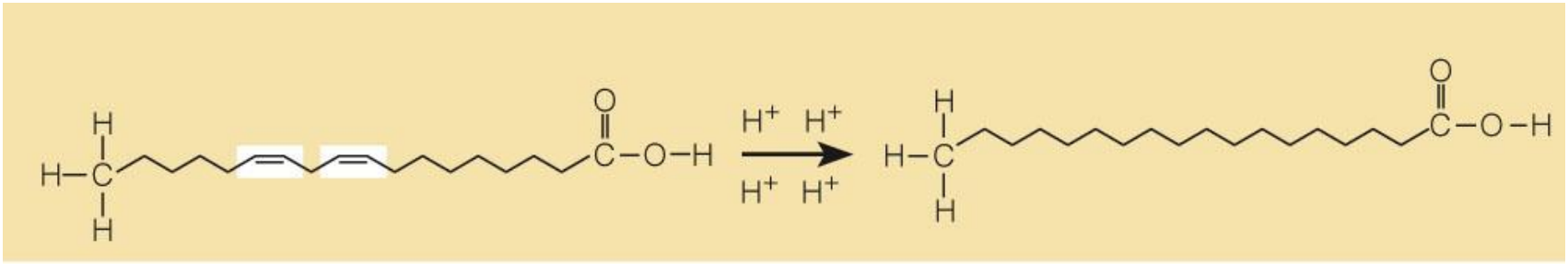
Characteristics of solid fats and oils

- **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

Hydrogenation

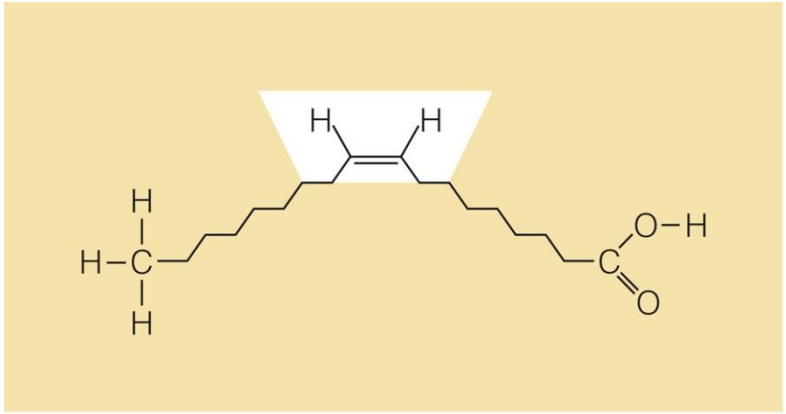


Polyunsaturated fatty acid

Hydrogenated (saturated) fatty acid

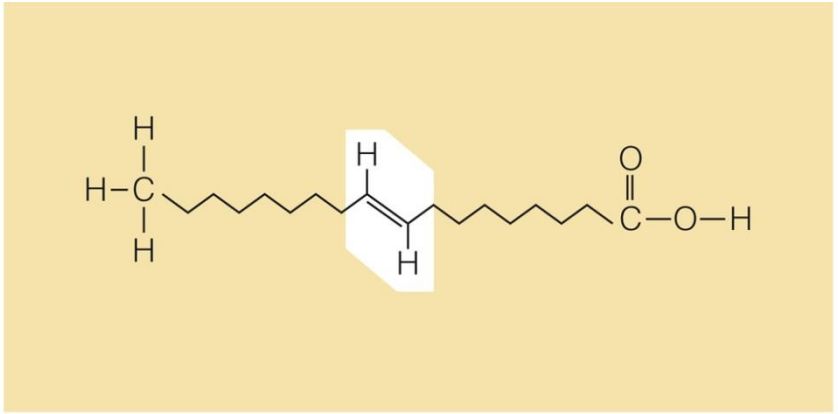
Double bonds carry a slightly negative charge and readily accept positively charged hydrogen. Most often fat is *partially hydrogenated*, creating a *trans*-fatty acid.

Cis-and Trans-Fatty Acids Compared



cis-fatty acid

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 occuring unsaturated fatty acids in foods are *cis*.



trans-fatty acid

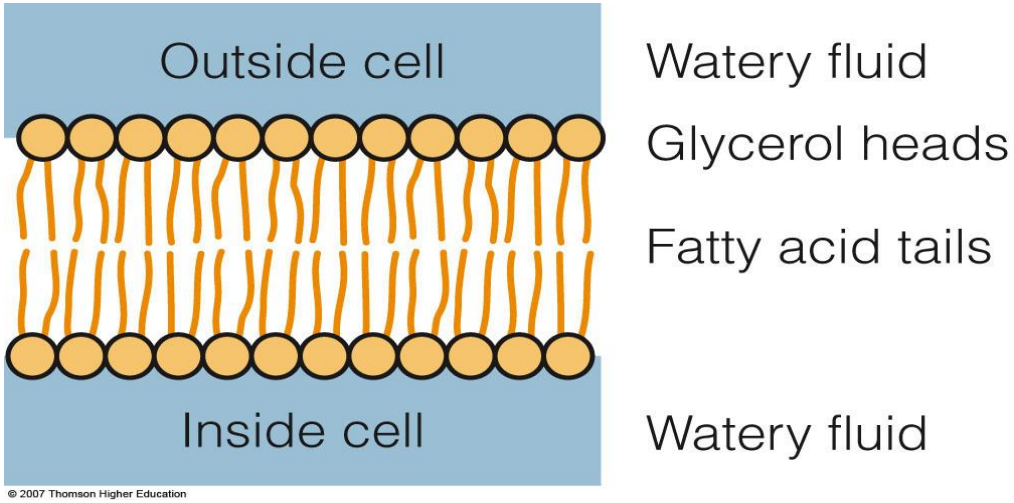
A *trans*-fatty acid has its hydrogens on the opposite sides of the double bond; *trans* molecules are more linear. The *trans* form typically occurs in partially hydrogenated foods when hydrogen atoms shift around some double bonds and change the configuration from *cis* to *trans*.

Characteristics of solid fats and oils

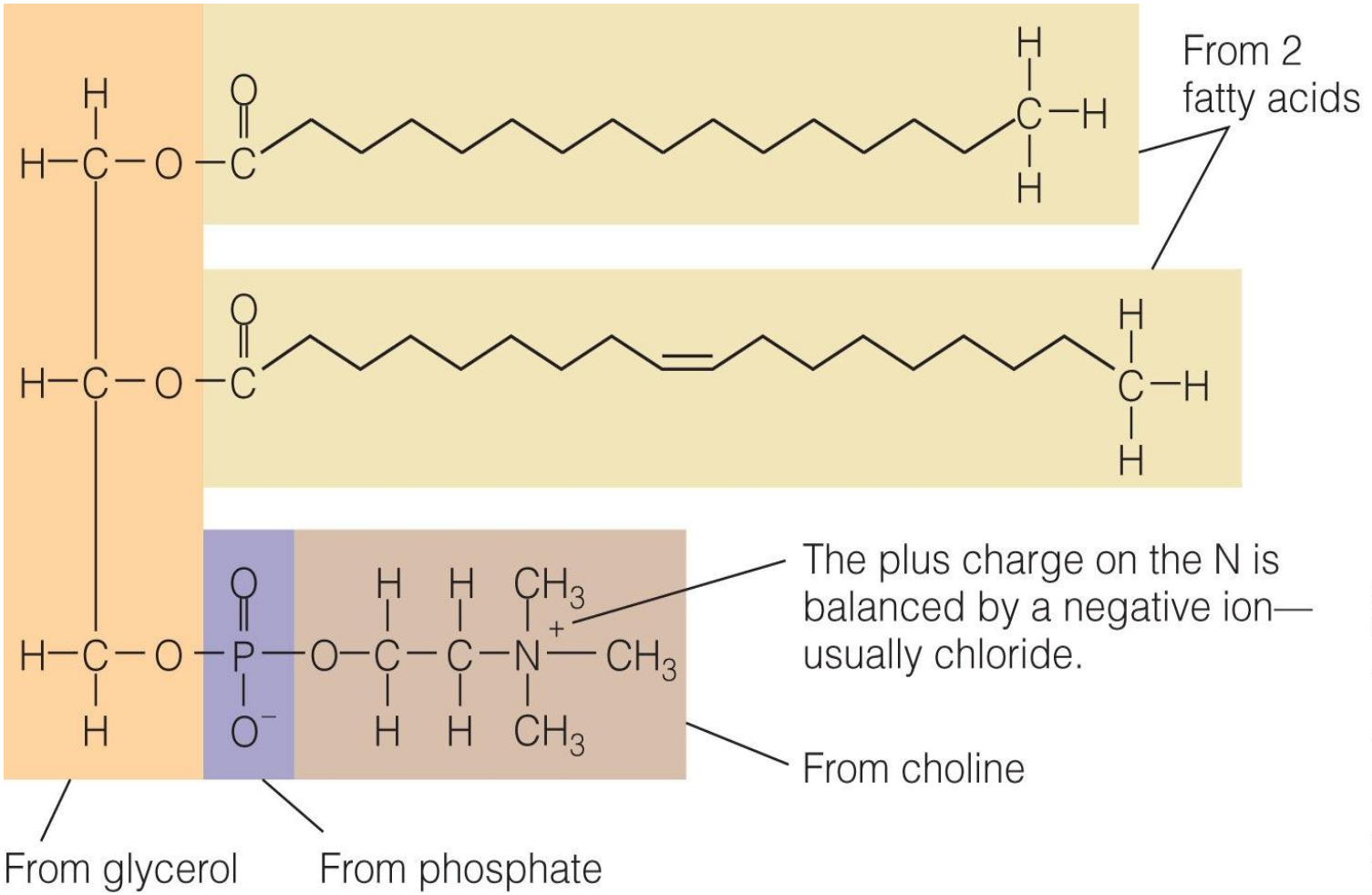
- Hydrogenated Vegetable Oil
  - Prevents spoilage of unsaturated fats
  - Hydrogenated oil is used in frying
    - Can be heated to high temperature
  - Easy to handle, easy to spread
  - Once fully hydrogenated, an oil loses both its unsaturated character and health benefits
  - The stick margarines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

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



Lecithin



Phospholipids

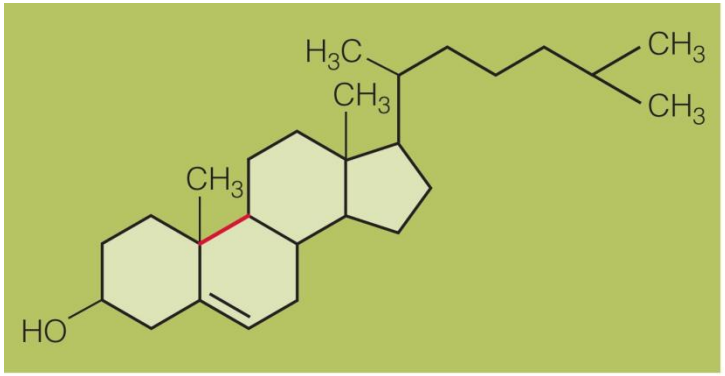
- Phospholipids in food
  - Found in foods such as eggs, liver, soybeans, wheat germ, peanuts
  - Used in food industry as emulsifiers in foods such as mayonnaise and salad dressings and candy bars

Sterols

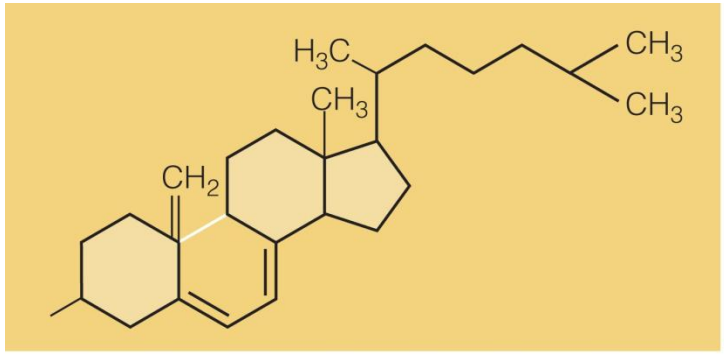
- **Sterols in Food:**
  - Most common one is **cholesterol**;
    - Found only in foods of animal origin
    - Meat, eggs, fish and poultry, dairy
  - Plant sterols (phytosterols)
    - Naturally found plants but in very low levels
    - Plant sterols block cholesterol absorption
    - Plant sterols 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 materiel to make these compounds

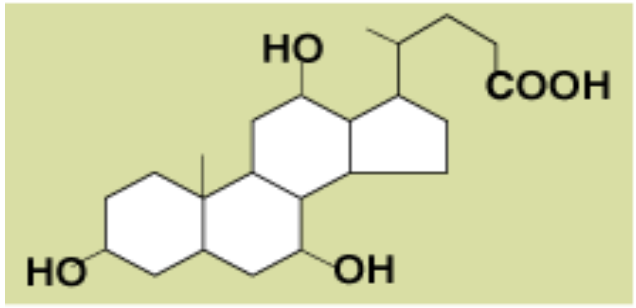


Cholesterol

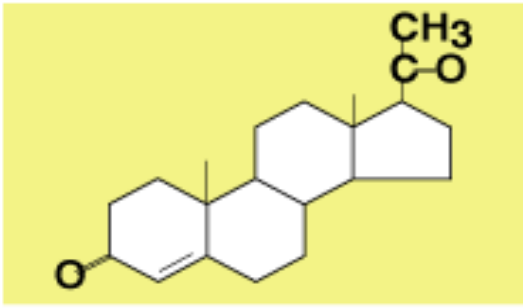


Vitamin D_3

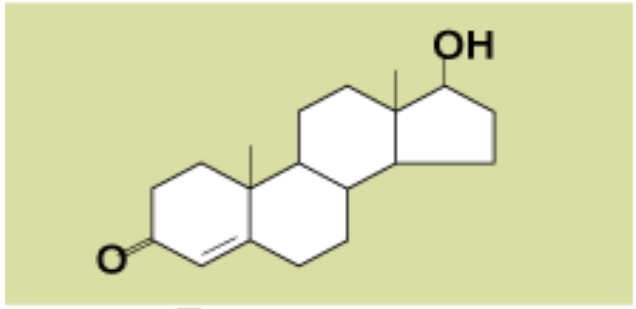
Cholic Acid and the Sex Hormones



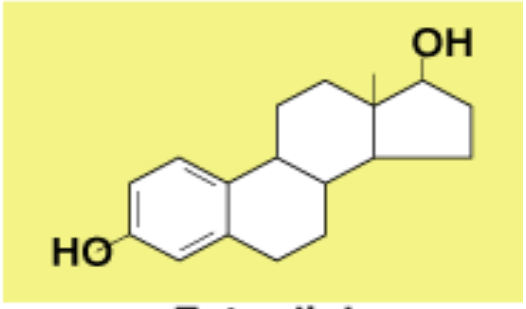
Cholic Acid



Progesterone



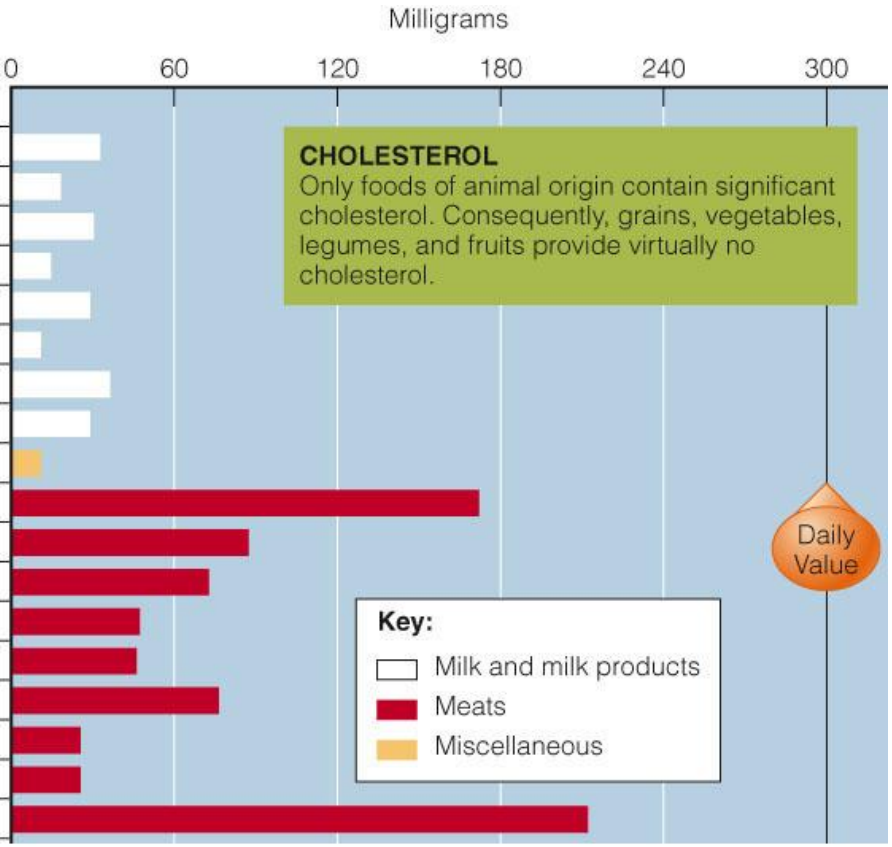
Testosterone



Estradiol

Cholesterol Content of Common Foods

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

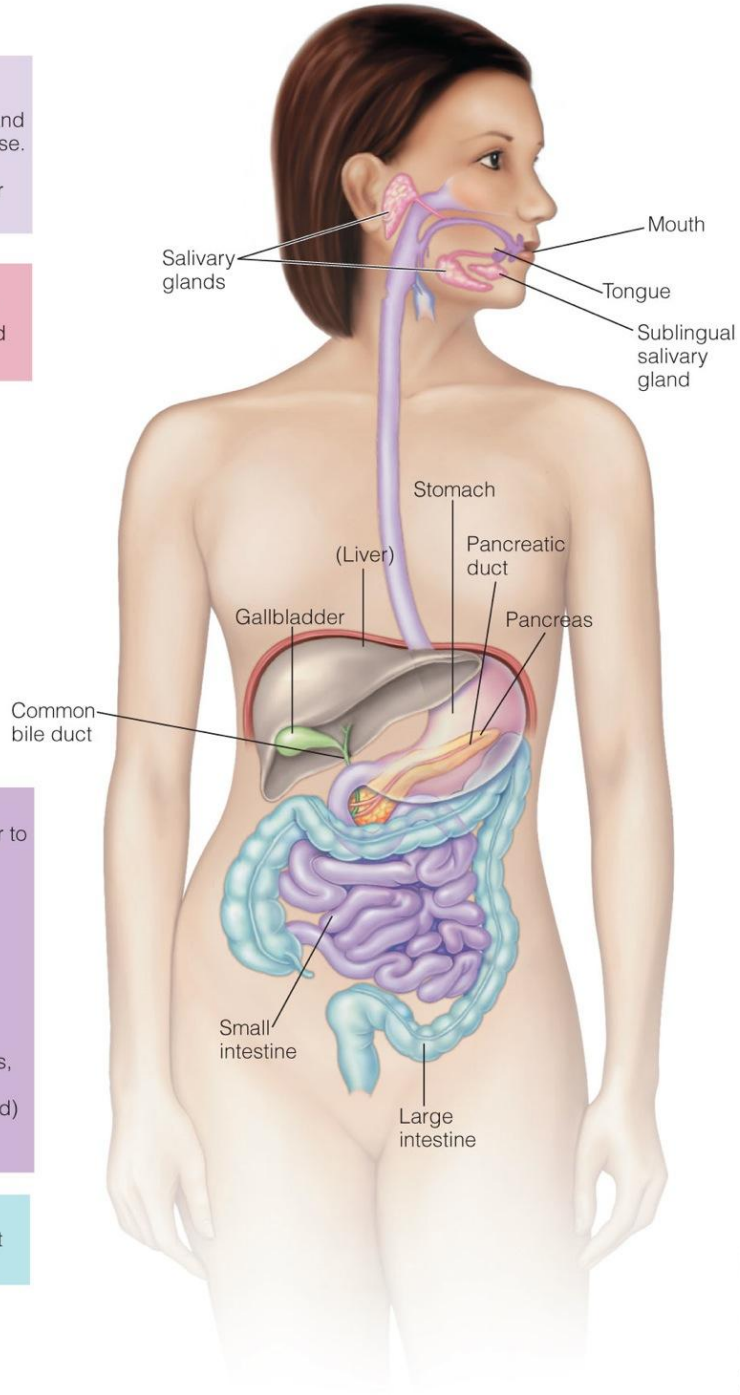


Lipid Digestion In the GI Tract

FAT

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):

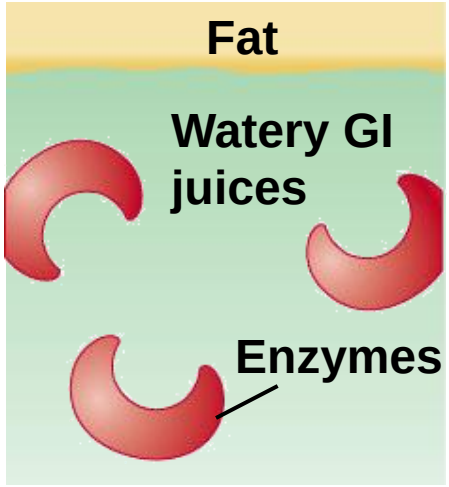
Fat —(Bile)→ Emulsified fat

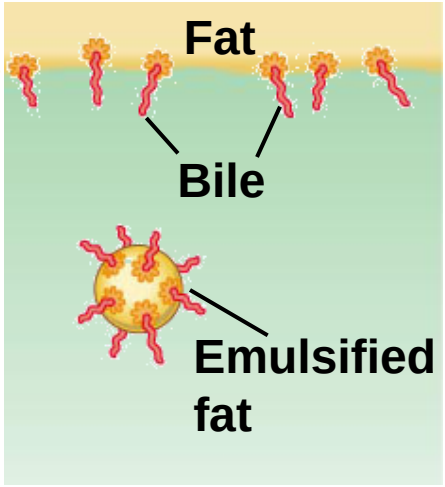
Pancreatic lipase flows in from the pancreas (via the pancreatic duct):

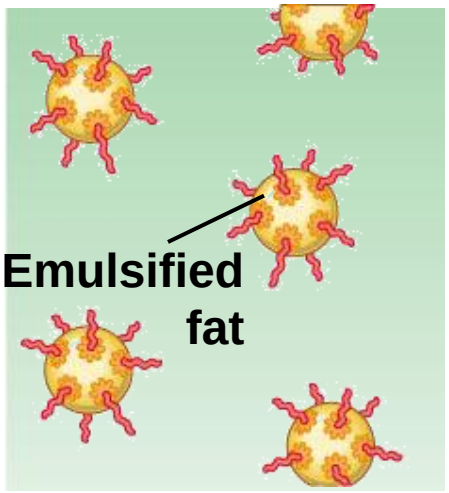
Emulsified fat (triglycerides) —(Pancreatic (and intestinal) lipase)→ Monoglycerides, glycerol, fatty acids (absorbed)

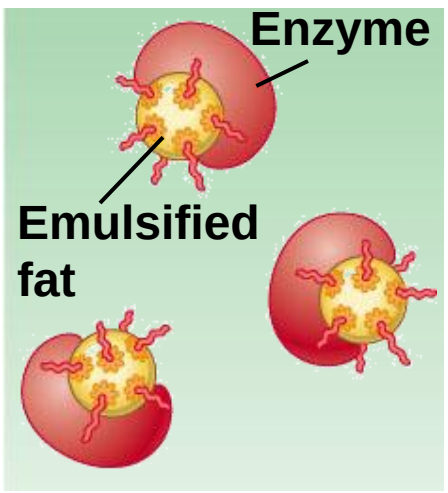
Large intestine
Some fat and cholesterol, trapped in fiber, exit in feces.

The Emulsification of Fat by Bile









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.

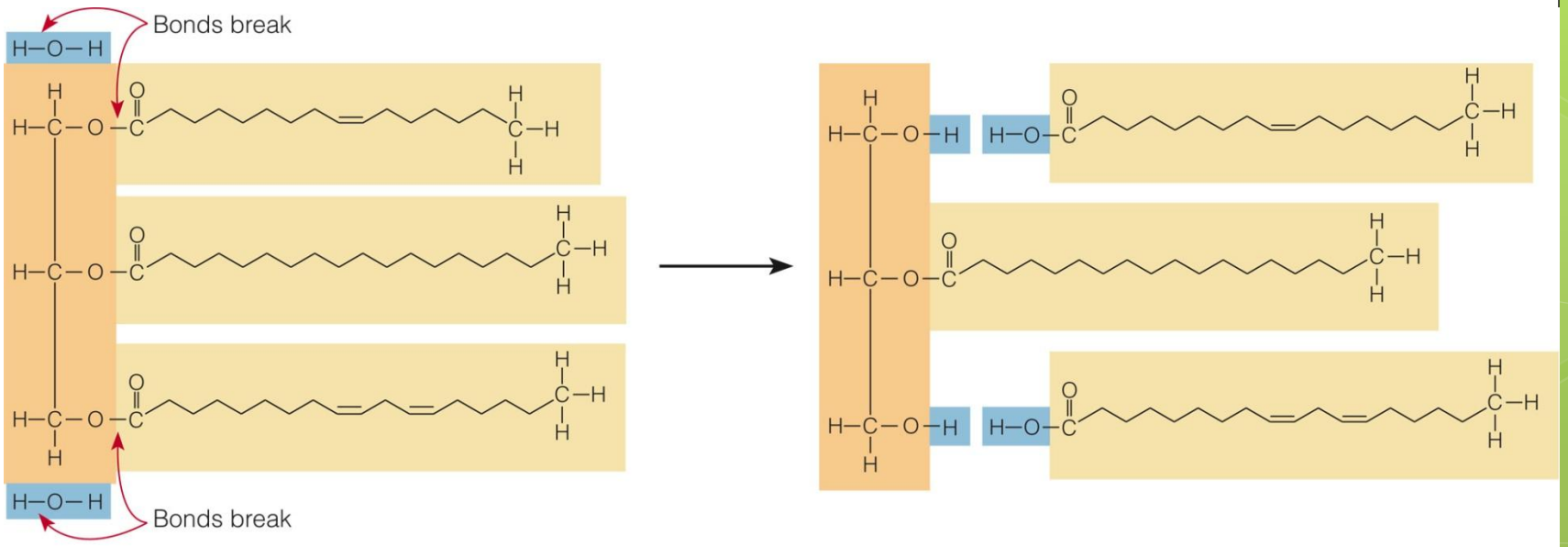
Bile's emulsifying action converts large fat globules into small droplets that repel each other.

After emulsification, more fat is exposed to the enzymes, making fat digestion more efficient.

Stepped Art

Fig. 5-14, p. 150

Hydrolysis of a Triglyceride



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.

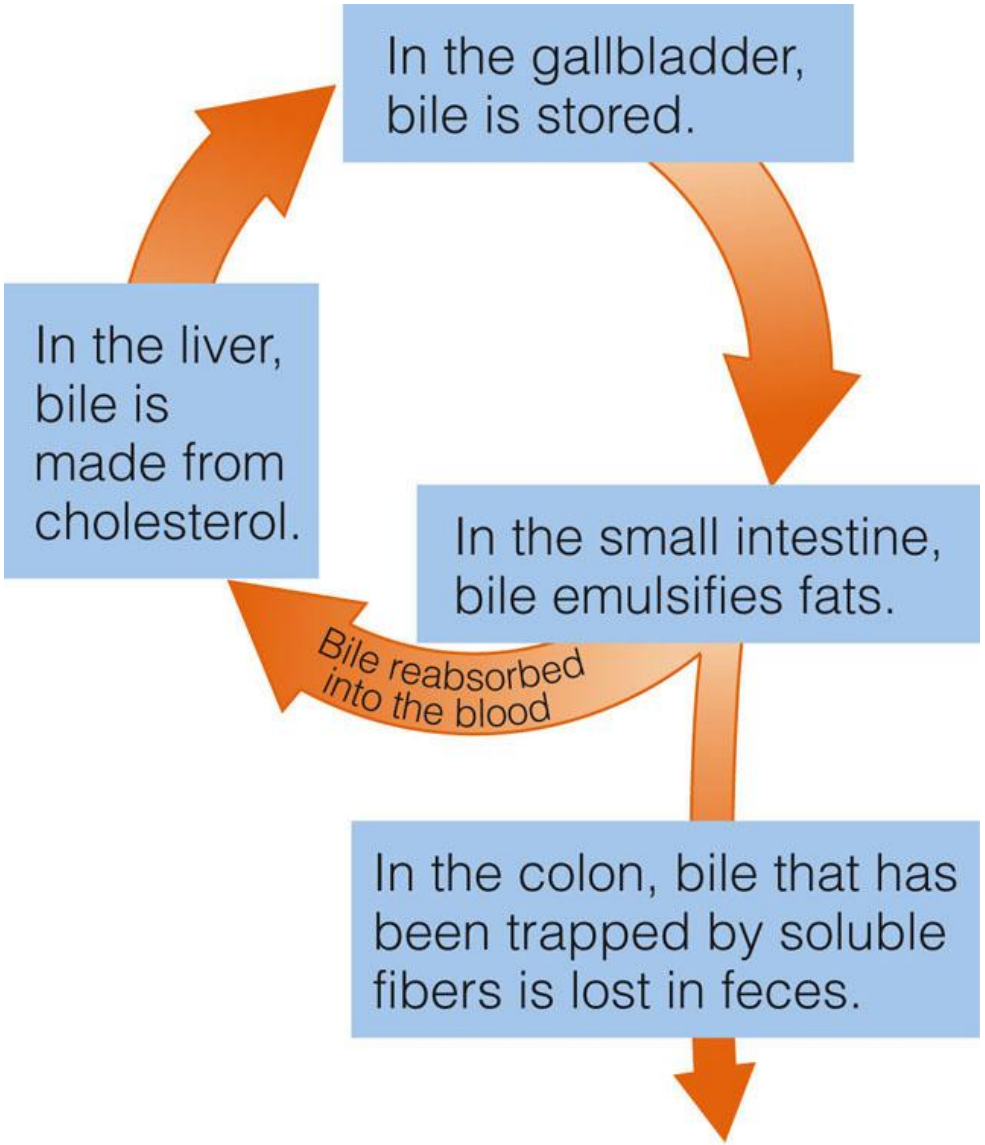
Monoglyceride + two fatty acids

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.

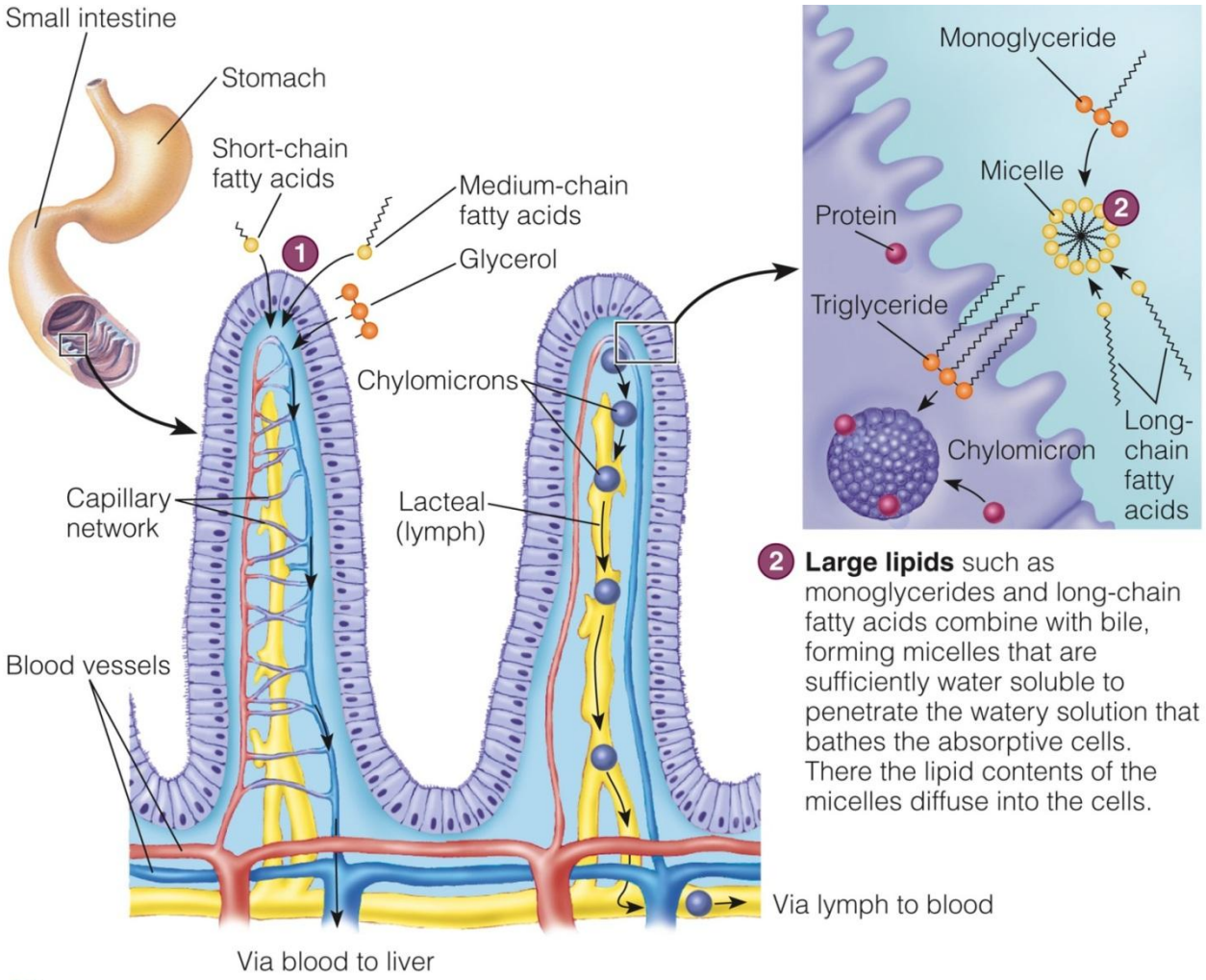
Bile's Routes

Enterohepatic circulation

Reabsorbed and recycled



Absorption of Fat



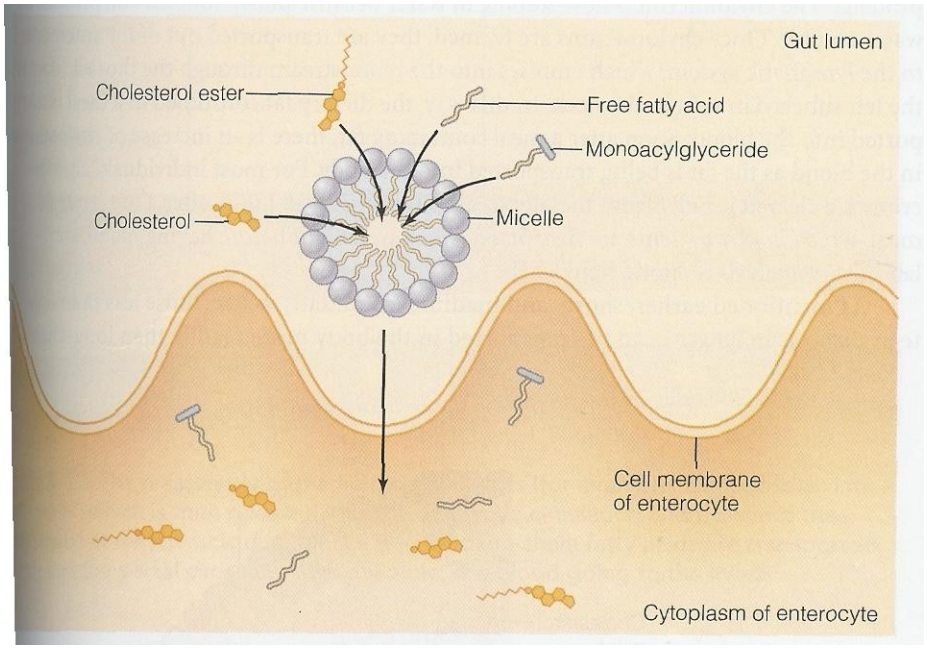
2 **Large lipids** such as monoglycerides and long-chain fatty acids combine with bile, forming micelles that are sufficiently water soluble to penetrate the watery solution that bathes the absorptive cells. There the lipid contents of the micelles diffuse into the cells.

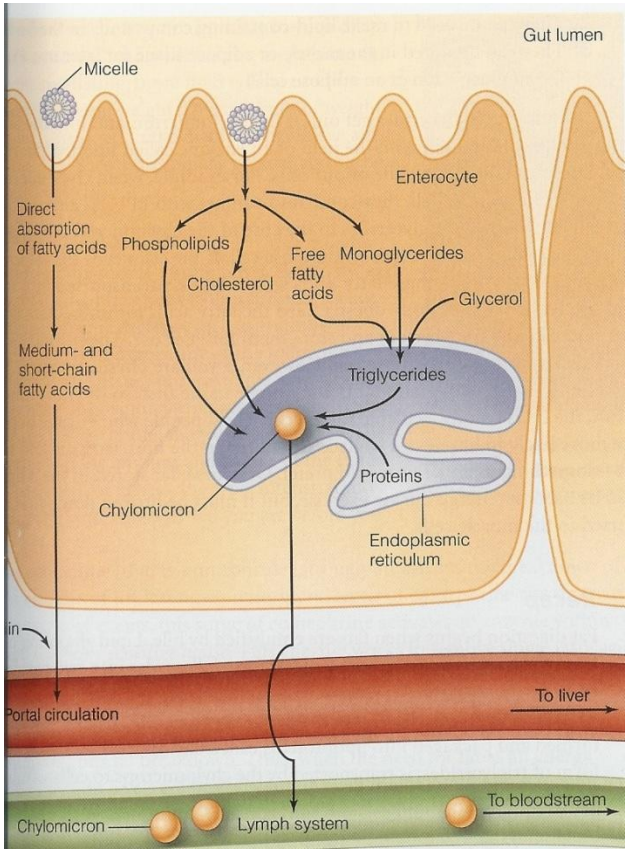
1 **Glycerol and small lipids** such as short- and medium-chain fatty acids can move directly into the bloodstream.

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

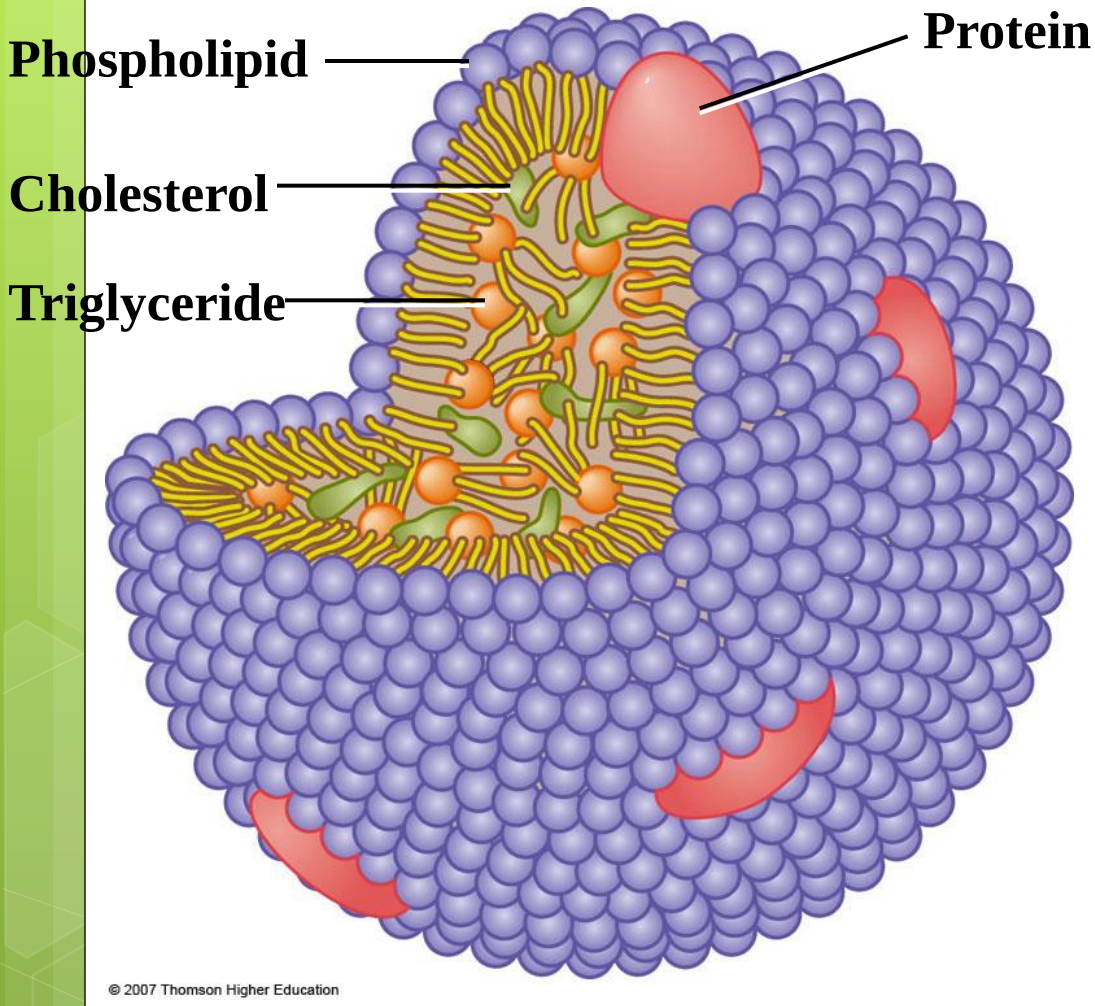
Fat Absorption





http://nutrition.jbpub.com/animations/animations.cfm?id=11&debug=0

A Typical Lipoprotein



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.

Fig. 5-18b, p. 146

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)

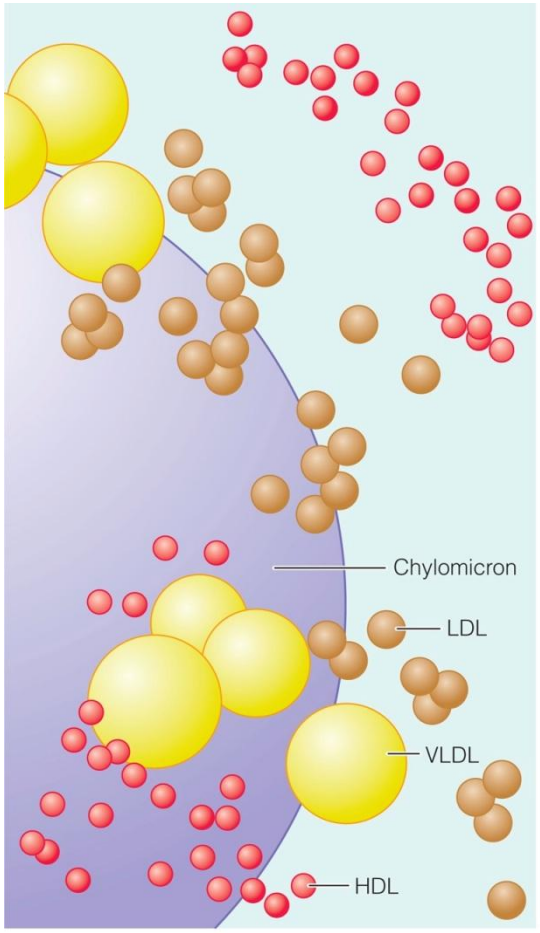
- Composed primarily of **cholesterol**
- Circulate throughout the body and release triglyceride, cholesterol and phospholipid to body cells.
- Body cells collect the lipids and use them to make cell membranes, hormones, or store for later use.
- Liver removes LDL from circulation
- Often termed "**Bad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

Lipid Transport

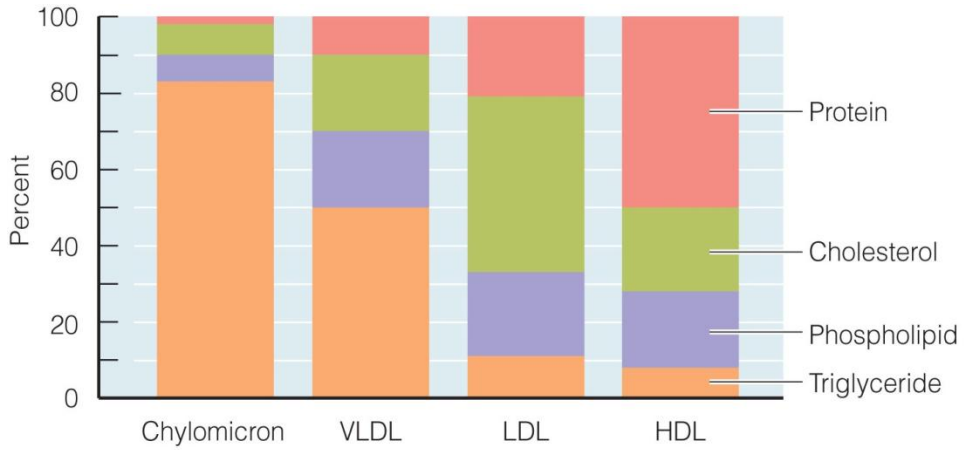
High Density Lipoprotein (HDL)

- 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.



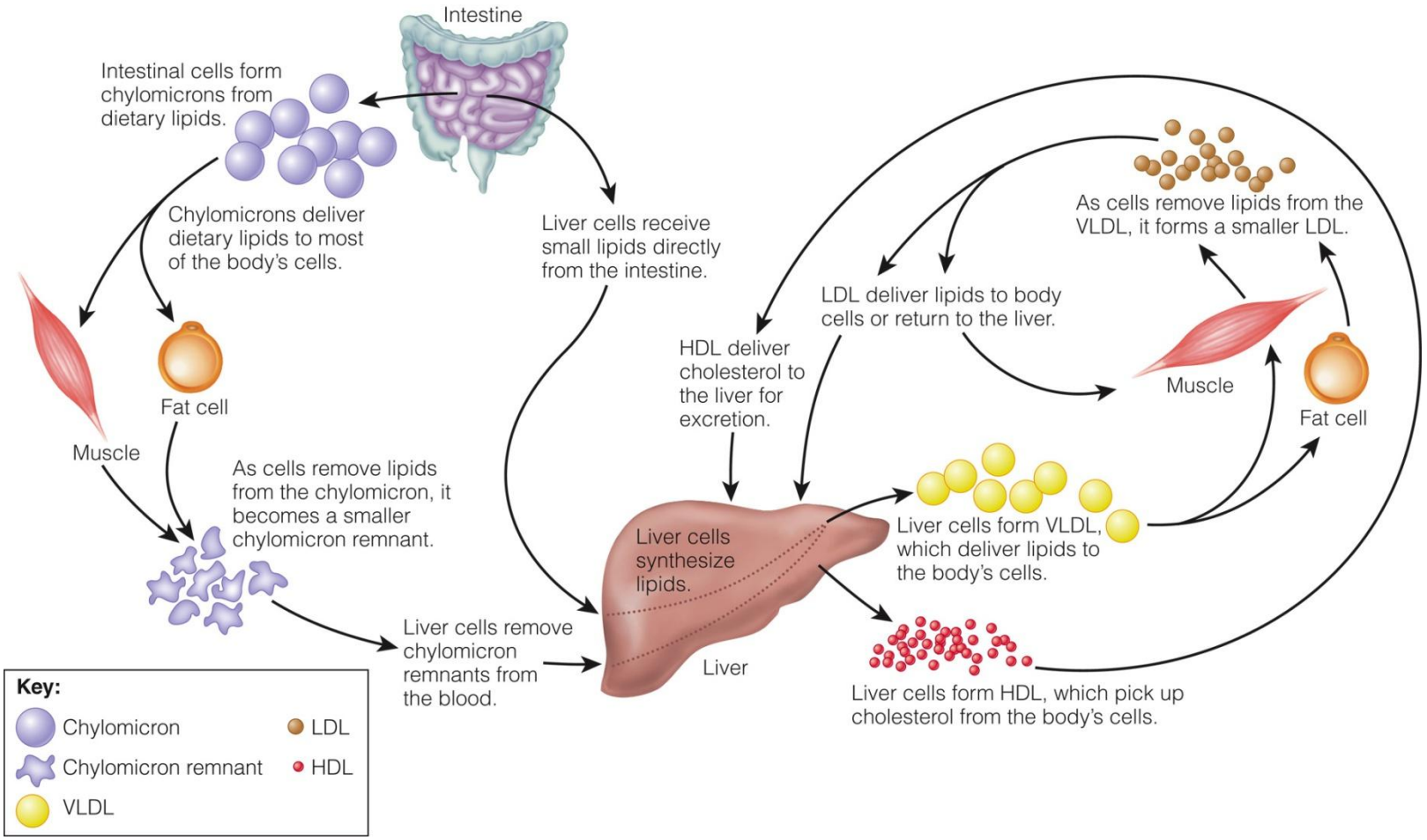
Chylomicrons contain so little protein and so much triglyceride that they are the lowest in density.

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



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

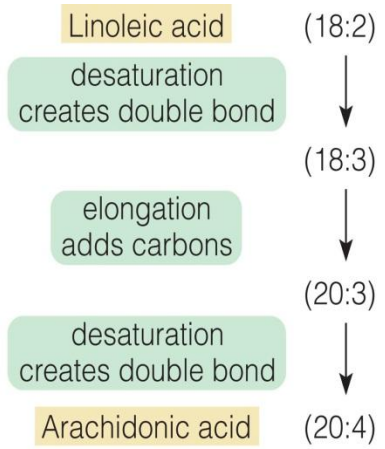
The Role of Triglycerides

Fats in Food	Fats in the Body
■ Provide essential fatty acids. ■ Provide a concentrated energy source in foods. ■ Carry fat-soluble vitamins A, D, E, and K, and assist in their absorption. ■ Provide raw material for making needed products. ■ Contribute to taste and smell of foods. ■ Stimulate the appetite. ■ Contribute to feeling of fullness. ■ Help make foods tender.	■ Are the body's chief form of stored energy. ■ Provide most of the energy to fuel muscular work. ■ Serve as an emergency fuel supply in times of illness and diminished food intake. ■ Protect the internal organs from shock through fat pads inside the body cavity. ■ Insulate against temperature extremes through a fat layer under the skin. ■ Form the major material of cell membranes. ■ Are converted to other compounds, such as hormones, bile, and vitamin D, as needed.

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

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

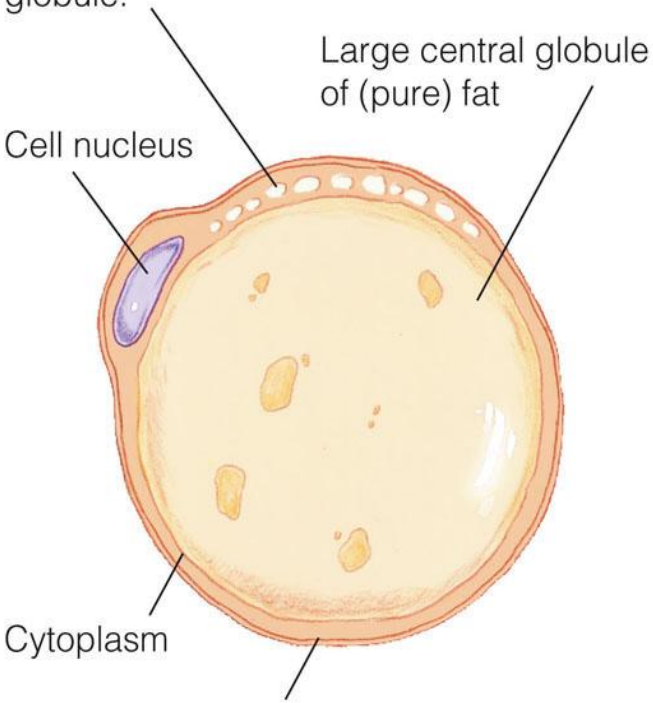
Lipid Metabolism

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.



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.

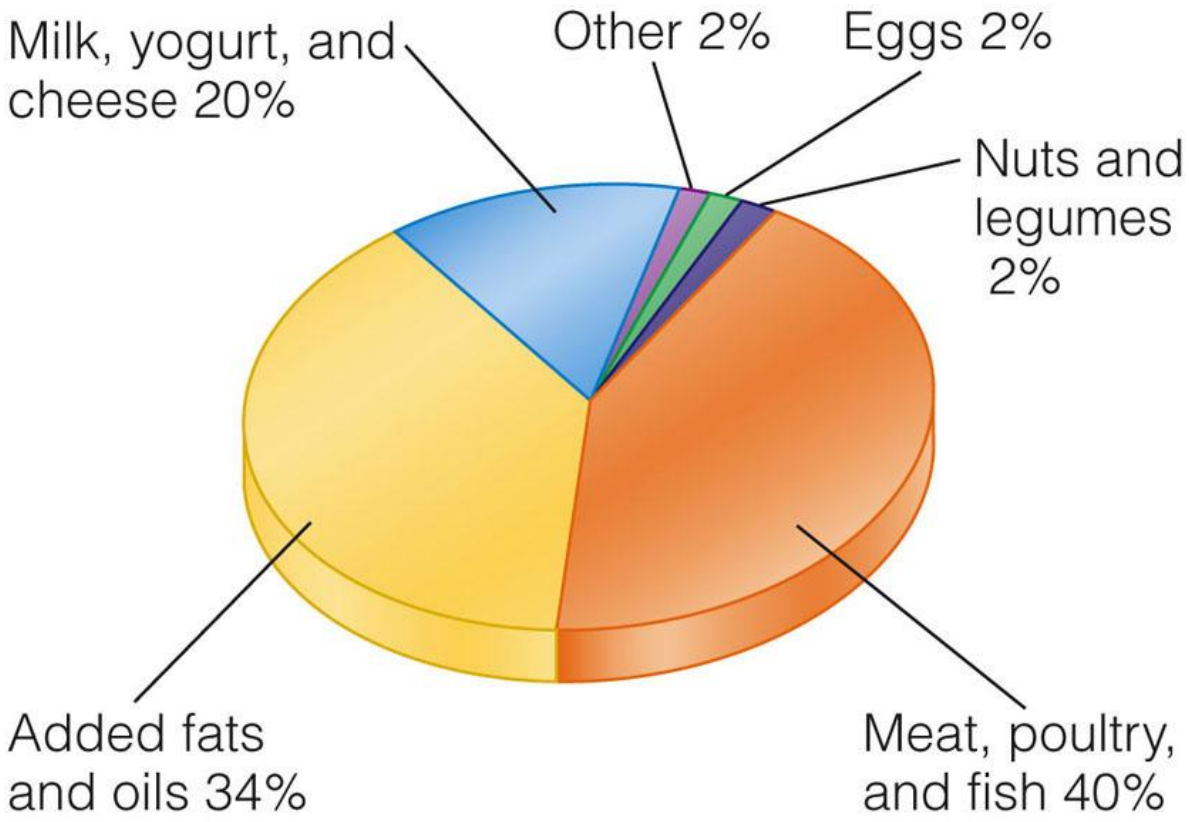
Health Effects of Saturated Fats

Heart Disease

- Leading cause of death in adults
- Elevated LDL cholesterol is a major risk factor for heart disease
- Cholesterol based plaque buildup restricts and blood flow and raises blood pressure
- **Saturated fats** raise LDL cholesterol levels much more dramatically than food cholesterol and promote blood clotting

Health Effects of Saturated Fats

- 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
- 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



Saturated Fats In the U.S. Diet

Note that fruits, grains, and vegetables are insignificant sources, unless saturated fats are intentionally added to them during preparation.

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%	

Not a significant source of dietary fiber, sugars, vitamin C, calcium, and iron.

*Percent Daily Values are based on a 2,000 calorie diet.

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%	

Not a significant source of dietary fiber, sugars, vitamin C, calcium, and iron.

*Percent Daily Values are based on a 2,000 calorie diet.

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 2g	
Polyunsaturated Fat 4g	
Monounsaturated Fat 2.5g	
Cholesterol 0mg	0%
Sodium 80mg	3%
Total Carbohydrate 0g	0%
Protein 0g	
Vitamin A 10%	

Not a significant source of dietary fiber, sugars, vitamin C, calcium, and iron.

*Percent Daily Values are based on a 2,000 calorie diet.

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

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 8g	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%	

Not a significant source of dietary fiber, sugars, vitamin C, calcium, and iron.

*Percent Daily Values are based on a 2,000 calorie diet.

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
  - The DRI and the Dietary Guidelines recommend:
    - 20-35% of energy intake from fat
    - Limiting 10% of energy intake from saturated fat
    - As little trans fat as possible
    - Less than 300 mg of cholesterol

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

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 5-4 Sources of Omega-3 and Omega-6 Fatty Acids

Omega-3	
Linolenic acid	Oils (canola, flaxseed, soybean, walnut, wheat germ, liquid or soft margarine made from canola or soybean oil)
	Nuts and seeds (flaxseeds, walnuts, soybeans)
	Vegetables (soybeans)
EPA and DHA	Human milk
	Fish and seafood:
	>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 Chilian seabass), trout (wild and farmed)
	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)
	<150 mg per 3.5 oz serving: cod (Pacific), grouper, lobster, mahimahi, monkfish, red snapper, skate, triggerfish, tuna, wahoo
Omega-6	
Linoleic acid	Seeds, nuts, vegetable oils (corn, cottonseed, safflower, sesame, soybean, sunflower), poultry fat

Source for fish data: K. L. Weaver and coauthors. The content of favorable and unfavorable polyunsaturated fatty acids found in commonly eaten fish, *Journal of the American Dietetic Association* 108 (2008): 1178–1185; P. M. Kris-Etherton, W. S. Harris, and L. J, Appel , Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease, *Circulation* 106 (2002): 2747–2757.

Recommended Intakes of Mono- & Polyunsaturated Fats

- 20 to 35 percent of kcalories from fat
  - Includes essential fatty acids
- DRI
  - Linoleic acid – 5-10% of daily energy
  - Linolenic acid – 0.6-1.2% of daily energy

Replacing Saturated with Unsaturated Fat

TABLE 5-3 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.

Replace these foods . . .

	Saturated Fat (g)	Unsaturated Fat (g)	Total Fat (g)
Butter (1 tbs)	7	4	11
Bacon (2 slices)	3	6	9
Potato chips (10 chips)	2	5	7
Cheese (1 slice)	4	4	8
Steak (1½ oz)	2	3	5
Totals	**18**	**22**	**40**

. . . with these foods.

	Saturated Fat (g)	Unsaturated Fat (g)	Total Fat (g)
Olive oil (1 tbs)	2	9	11
Sunflower seeds (2 tbs)	1	7	8
Mixed nuts (2 tbs)	1	8	9
Avocado (6 slices)	2	8	10
Salmon (2 oz)	1	3	4
Totals	**7**	**35**	**42**

Replacing Saturated with Unsaturated Fat

SATURATED FATS MEAL

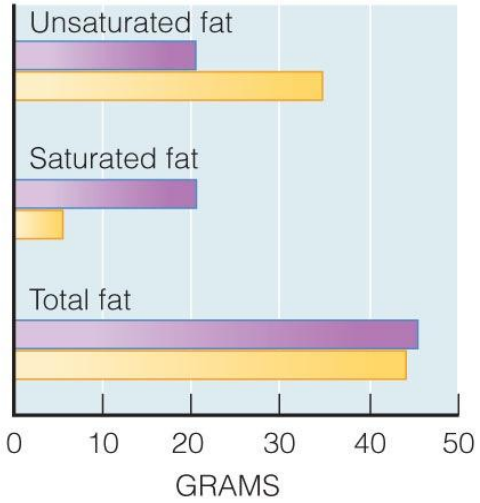
1 c fresh broccoli topped with
1 tbs butter

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

To lower saturated fat and raise monounsaturated and polyunsaturated fats . . .



UNSATURATED FATS MEAL

1 c fresh broccoli sautéed in
1 tbs olive oil

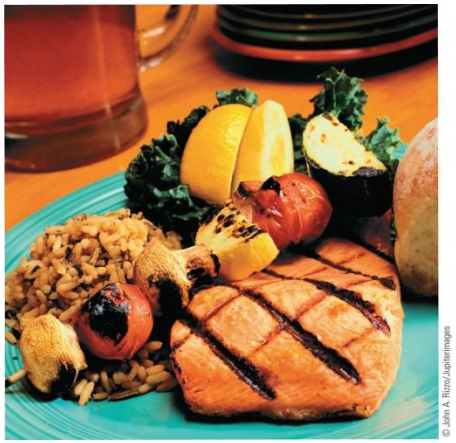
1 c mixed baby greens salad with
½ avocado
2 tbs sunflower seeds
1 tbs light Italian dressing

4 oz grilled salmon

Energy = 600 kcal

From Guidelines to Groceries

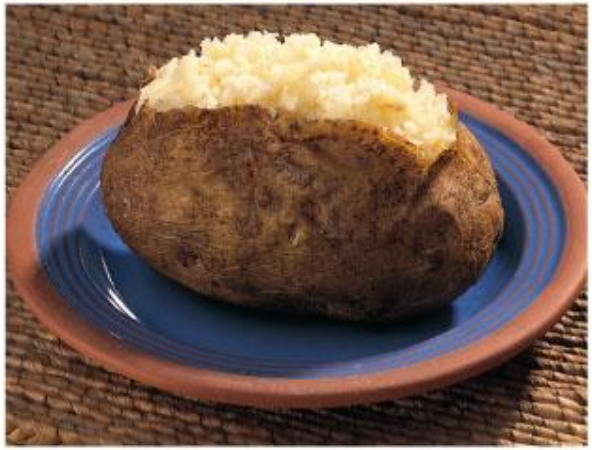
- Choose lean cuts of meat
- Have 2 servings of fish per week
- Choose fat-free and low-fat milks and milk products
- Vegetables, fruits, and grains
  - Lowers consumption of various fats in the diet
- Invisible fat
  - Fried and baked goods
- Choose wisely
  - Unprocessed foods



Pork chop with fat (340 kcal, 19 g fat, 7 g saturated fat).

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

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

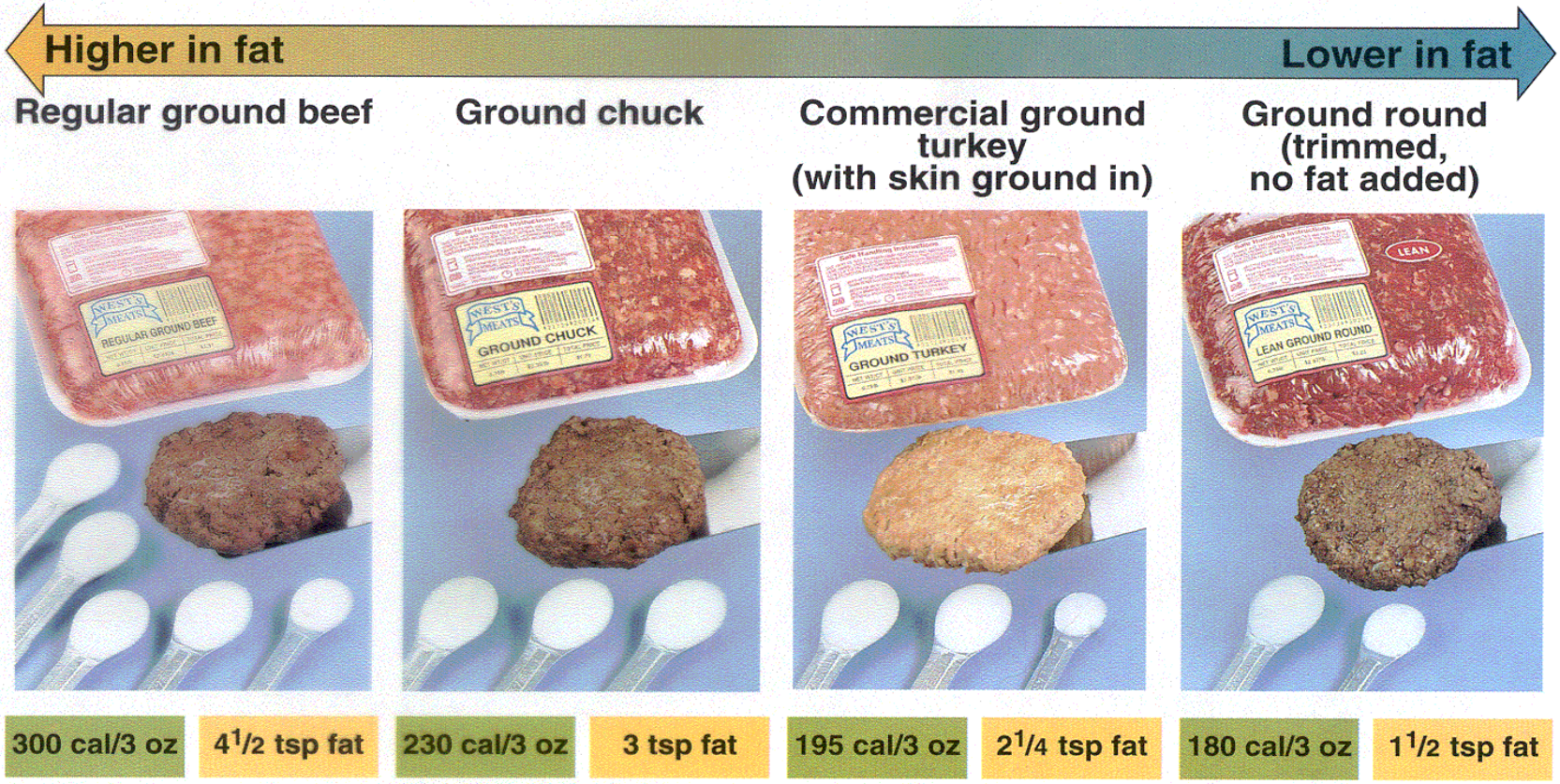


Plain potato (200 kcal, <1 g fat, 0 g saturated fat).

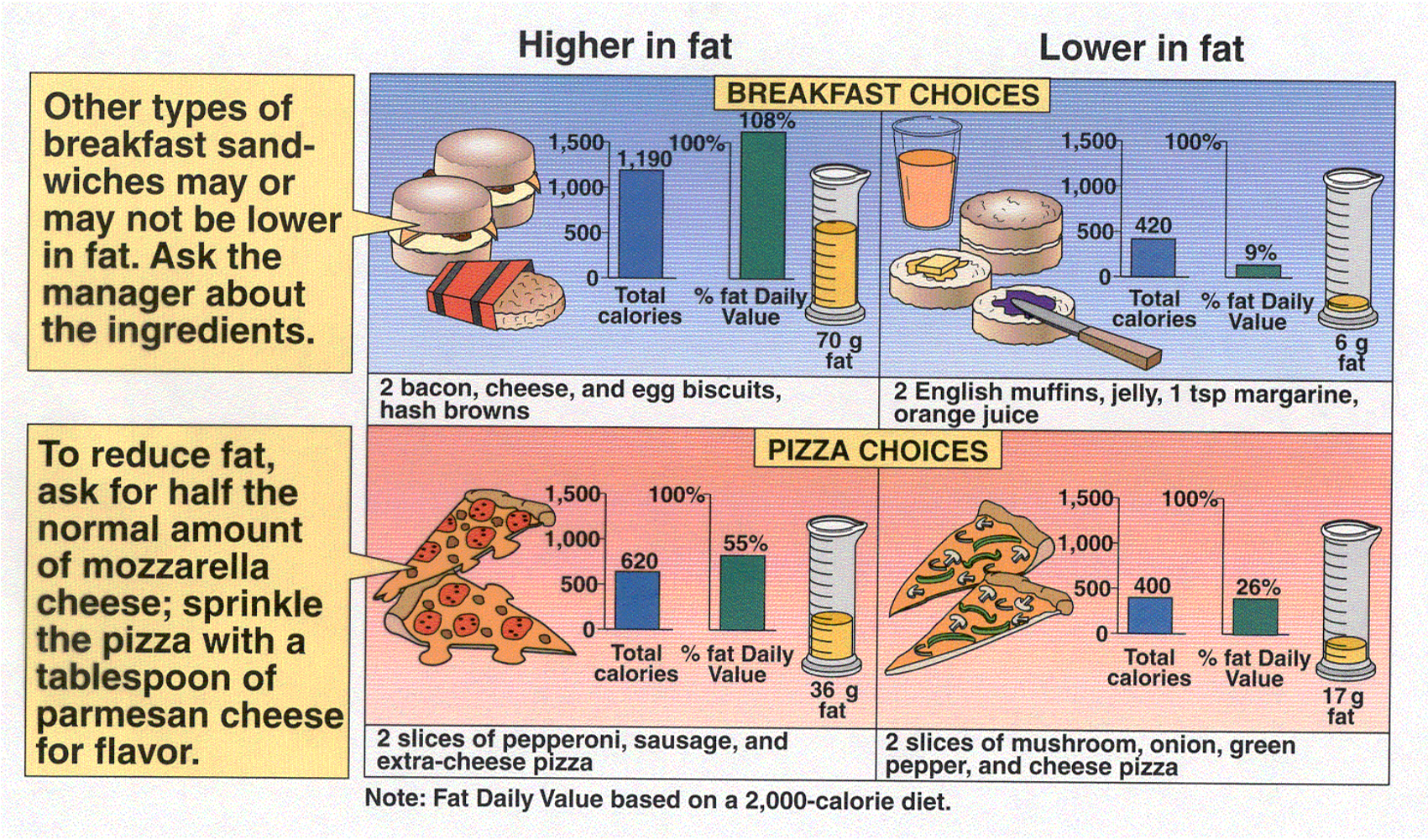
Whole milk, 1 c (150 kcal, 8 g fat, 5 g saturated fat).

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

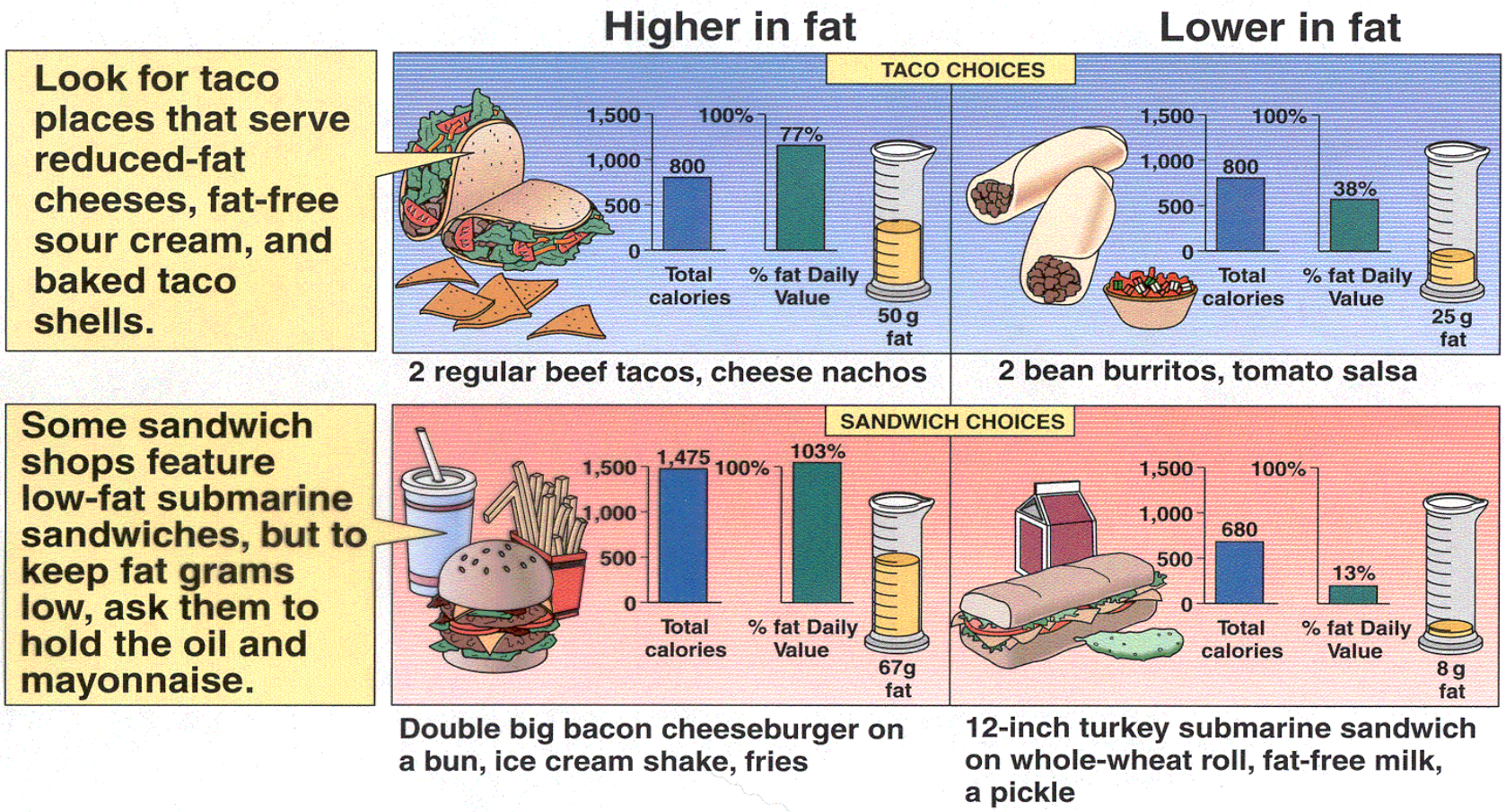
Fat in Ground Meats



Fast Food: Breakfast/Pizza Choices



Fast Food: Taco/Burger Choices



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 Dominos pizza pepperoni 614 kcal 24 g fat

High-Fat Foods and Heart Disease

TABLE H5-1 Major Sources of Various Fatty Acids

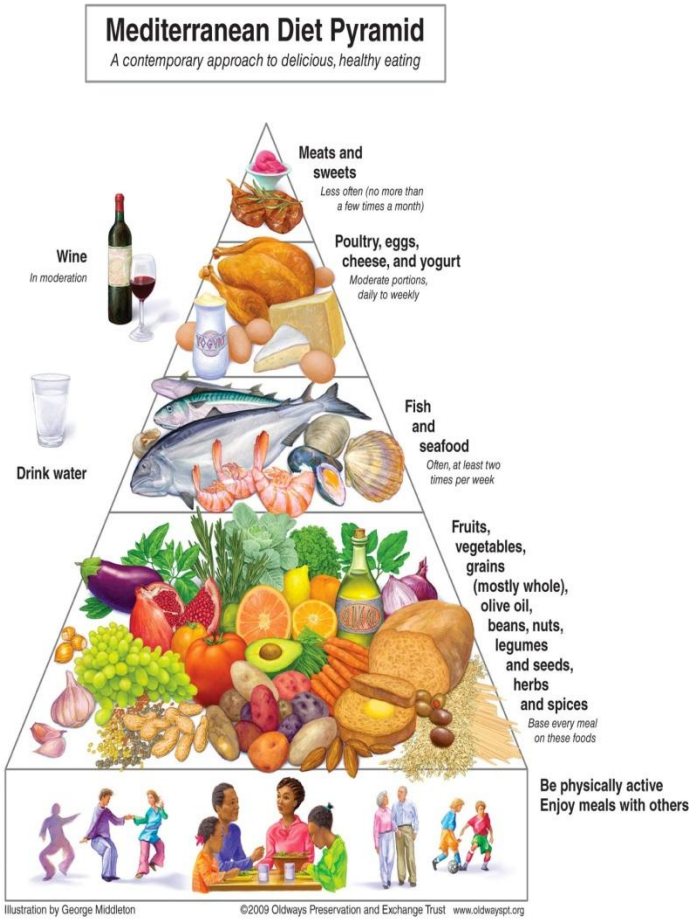
Healthful Fatty Acids Monounsaturated	Omega-6 Polyunsaturated	Omega-3 Polyunsaturated
Avocado	Margarine (nonhydrogenated)	Fatty fish (herring, mackerel, salmon, tuna)
Oils (canola, olive, peanut, sesame)	Oils (corn, cottonseed, safflower, soybean)	Flaxseed
Nuts (almonds, cashews, filberts, hazelnuts, macadamia nuts, peanuts, pecans, pistachios)	Nuts (pine nuts, walnuts)	Nuts (walnuts)
Olives	Mayonnaise	
Peanut butter	Salad dressing	
Seeds (sesame)	Seeds (pumpkin, sunflower)	
Harmful Fatty Acids **Saturated**	***Trans***	
Bacon	Fried foods (hydrogenated shortening)	
Butter	Margarine (hydrogenated or partially hydrogenated)	
Chocolate	Nondairy creamers	
Coconut	Many fast foods	
Cream cheese	Shortening	
Cream, half-and-half	Commercial baked goods (including doughnuts, cakes, cookies)	
Lard	Many snack foods (including microwave popcorn, chips, crackers)	
Meat		
Milk and milk products (whole)		
Oils (coconut, palm, palm kernel)		
Shortening		
Sour cream		

NOTE: Keep in mind that foods contain a mixture of fatty acids.

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



Calculate Personal Daily Value for Fat

1800 total kcal X 0.30 from fat = 540 kcal

540 fat kcal ÷ 9 kcal per gram = 60 g fat

kcal/day	30% from fat	fat g/day
1500	450	50
1800	540	60
2000	600	65
2200	660	73
2400	720	80
2800	840	93

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