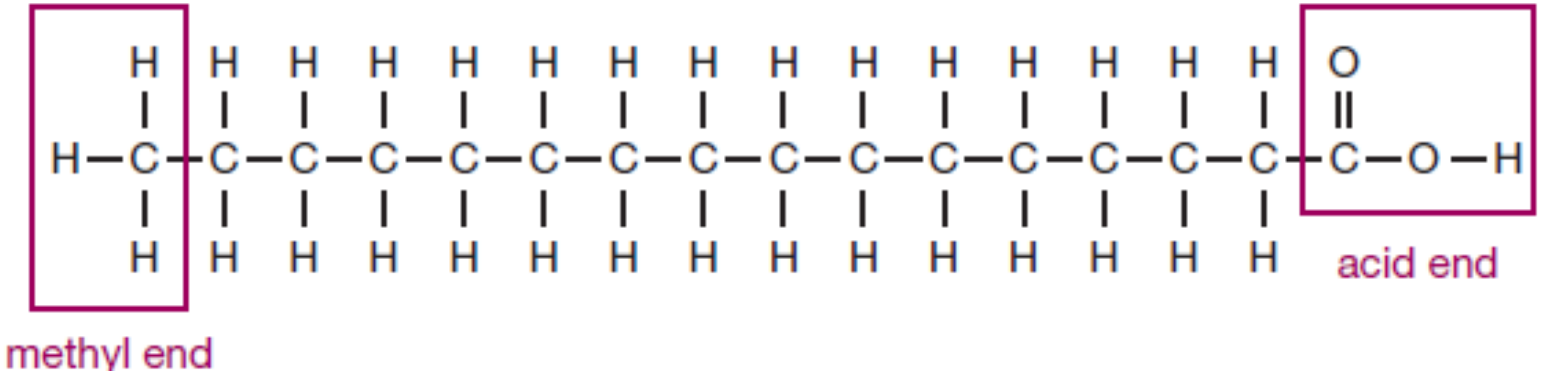
Chapter 4 : Lipids

Lipids

A group of water insoluble energy-yielding organic compounds composed of carbon, hydrogen, and oxygen atoms

Fatty AcidS

- chains of carbon atoms with hydrogen atoms attached
- Vary in :
  - Length of the carbon chain
  - Degree of saturation



Functions of essential fatty acids

- as part of phospholipids, essential Fatty acids are a component of cell membranes
- and are precursors of eicosanoids (a group of hormone-like substances that help regulate blood pressure, blood clotting, and other body functions)

Carbon Chain Length

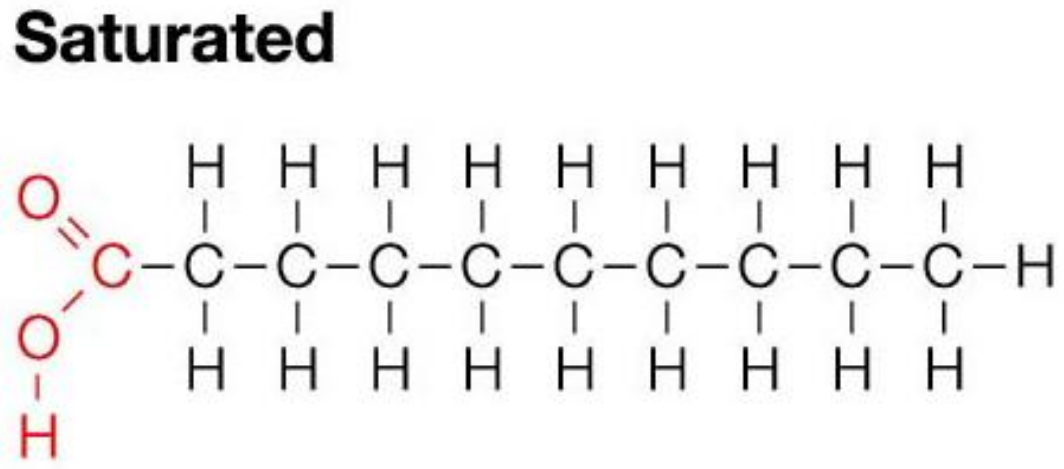
- Almost all of the chains have even number of carbon atoms

Short chain: 2 to 4
Medium chain: 6 to 10
Long chain: 12 or more

- Long-chain fatty acids:
  - meats, fish, and vegetables oils
- medium-and short chain fatty acids:
  - dairy products

Degree of Saturation

- **Saturated Fatty Acids:**
  - no double bonds exist between carbon atoms

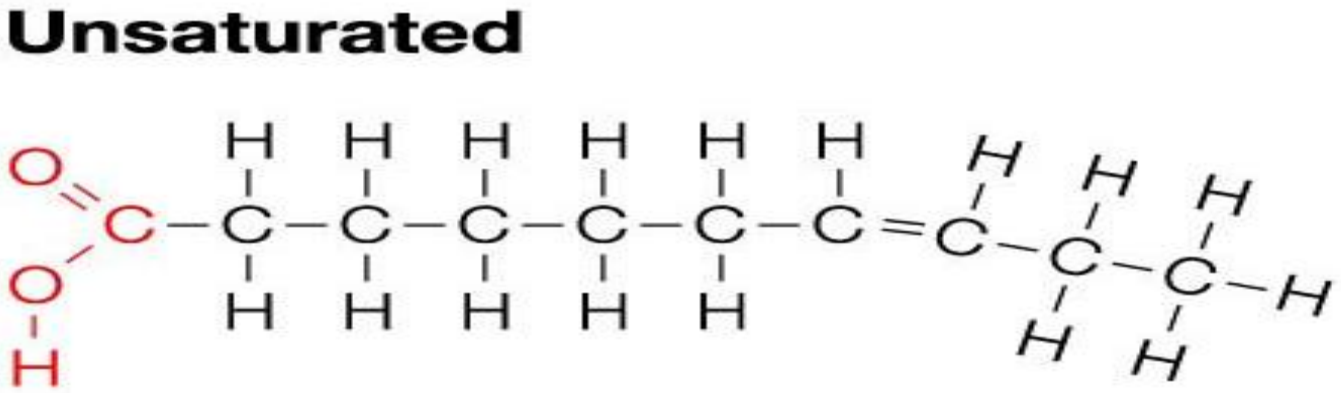


Degree of Saturation

- **Unsaturated Fatty Acids:**

  not completely saturated with hydrogen atoms, so one or more double bonds form between the carbon atoms.

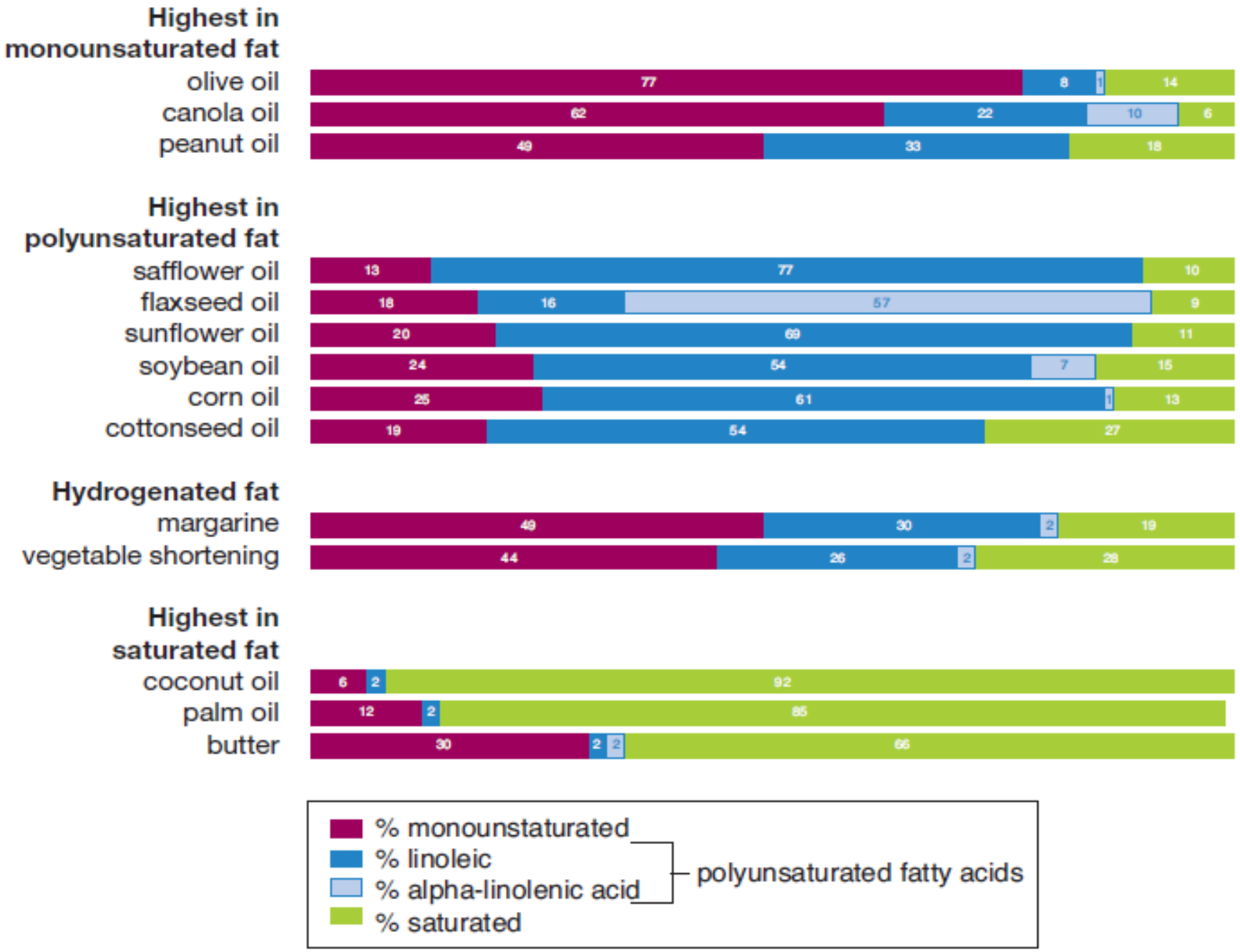
Monounsaturated vs. polyunsaturated



Degree of Saturation

- “unsaturated” and “saturated” are **NOT** absolute terms used to describe the only types of fatty acids present.

- They are relative descriptions that indicate which kinds of fatty acids are present in the largest proportion


Highest in monounsaturated fat
olive oil
77
8
1
14
canola oil
62
22
10
6
peanut oil
49
33
18
Highest in polyunsaturated fat
safflower oil
13
77
10
flaxseed oil
18
16
57
9
sunflower oil
20
69
11
soybean oil
24
54
7
15
corn oil
25
61
1
13
cottonseed oil
19
54
27
Hydrogenated fat
margarine
49
30
2
19
vegetable shortening
44
26
2
28
Highest in saturated fat
coconut oil
6
2
92
palm oil
12
2
86
butter
30
2
2
66
% monounstaturated
% linoleic
% alpha-linolenic acid
% saturated
polyunsaturated fatty acids

Saturated Fats

- They are basically straight-line molecules
- can pack tightly together and therefore tend to be solid at room temperature.

- Animal fats—the fat in meat, whole-milk dairy products, and egg yolks
- The only vegetable fats: palm oil, palm kernel oil, and coconut oil.

Saturated Fats

- Commonly known as a "bad" fat because it raises blood cholesterol levels

- May also make the inner lining of arteries more prone to inflammation and the buildup of fatty plaques
- **Reducing saturated fat intake** is one of the most important changes needed in the modern diet

Unsaturated Fats

- Are physically kinked and unable to pack together tightly thus they are liquid at room temperature

- Monounsaturated fats:
  - Olives, olive oil, canola oil, peanut oil, avocado, cashews, almonds, and most other nuts.
  - Meat fat (moderate amount)
- Polyunsaturated fats
  - corn, soybean, safflower, and cottonseeds oils, and also in fish.

Unsaturated Fats

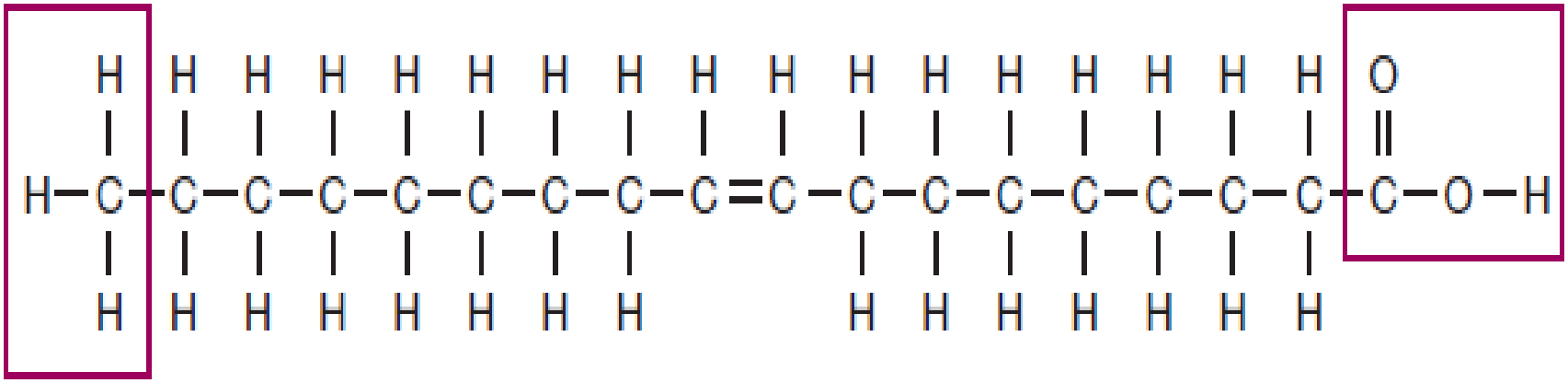
- Are commonly known as "good fats" because when they are eaten **in place of** saturated fats they lower LDL cholesterol and raise HDL cholesterol.

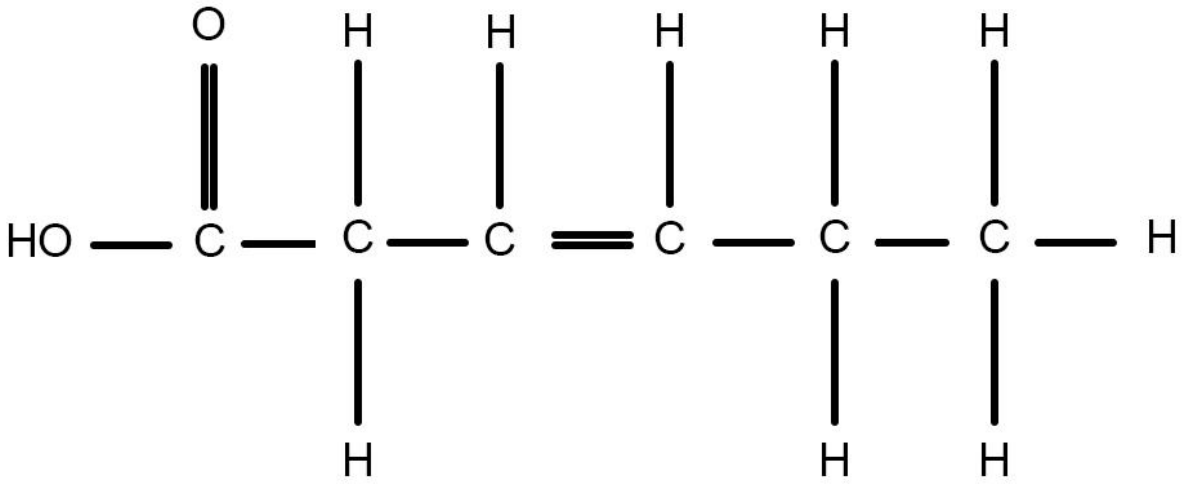
- When monounsaturated fats replace carbohydrates in the diet, improvements in triglyceride and HDL levels occur.

Position of the Double Bond

- location of the first or only double bond along the carbon chain.

- Count the number of carbon atoms from the methyl end, and denote it as "n" or omega





Position of the Double Bond

- The body is unable to insert double bonds closer than *n*-9 when it makes fatty acids

- so one *n*-6 fatty acid (linoleic acid) and one *n*-3 fatty acid (alpha-linolenic acid) are considered essential in the diet.

n- 6 fatty acid

- ***Linoleic Acid***
- It is especially abundant in :
  - plant oils such as safflower, sunflower, corn, and soybean oils
  - poultry fat
  - Nuts
  - seeds

n-3 fatty acids

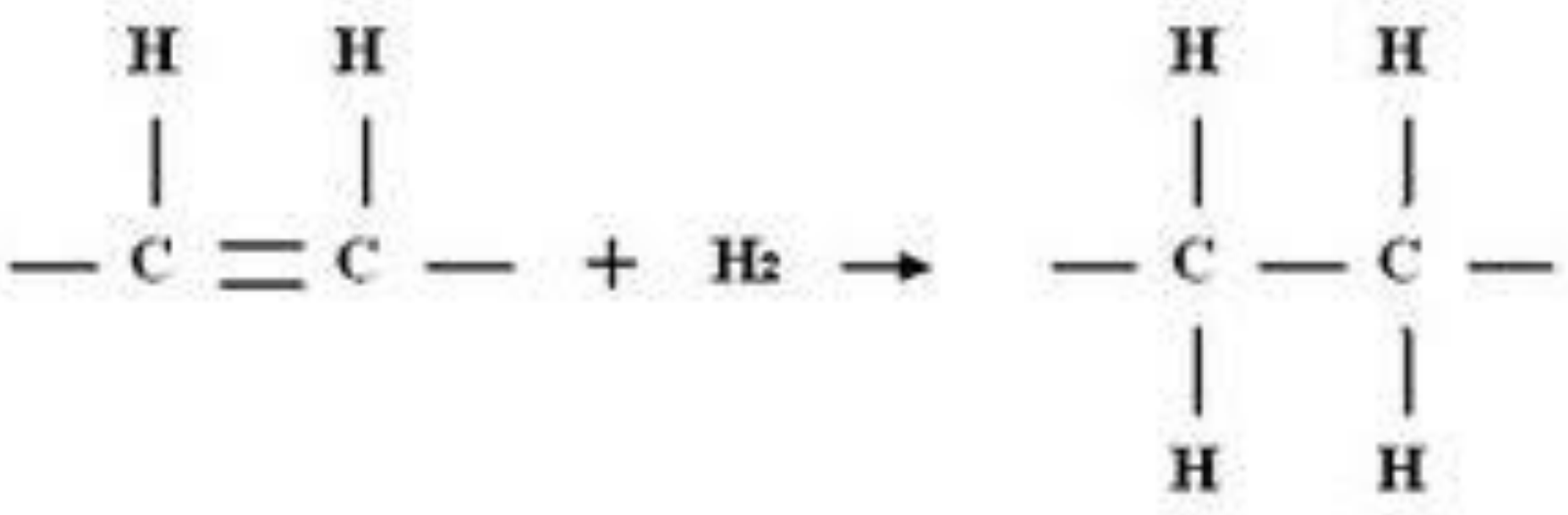
- ***Alpha-Linolenic Acid***
  - It is found in :
    - flaxseed, canola, soybean, and walnut oils
    - nuts, especially walnuts

Hydrogenation

- A process that adds hydrogen atoms to polyunsaturated oils to saturate some of the double bonds
- so that the resulting product is less susceptible to rancidity and has improved function

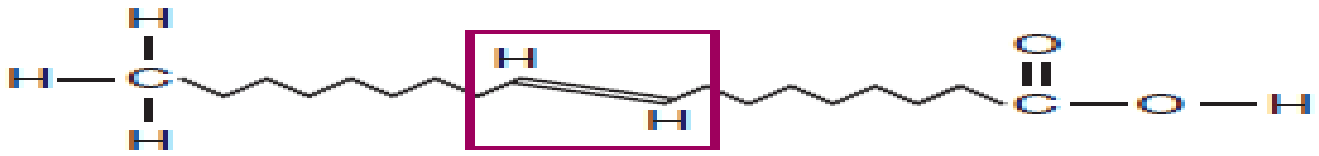
- Ex. Stick margarine and shortening

Hydrogenation

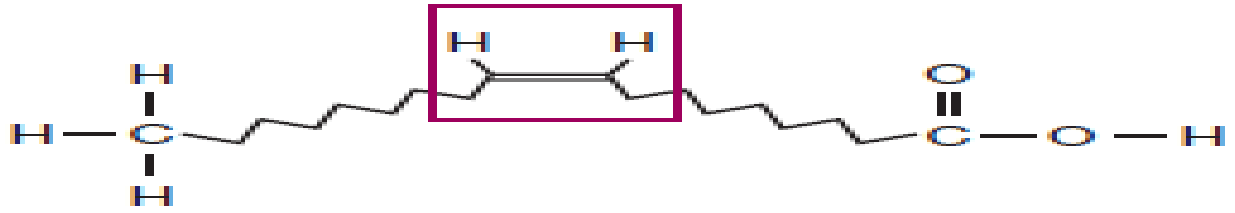


Hydrogenation

- The process of hydrogenation changes the placement of the hydrogen atoms around the remaining double bonds from the natural *cis* position to the rare *trans* position



Trans-position: H on opposite sides of double bond



Cis-position: H on same side of double bond

Trans Fats !!!!

- Raise LDL cholesterol.
- Lower HDL cholesterol
- Increase serum triglyceride levels
- Increase insulin resistance
- Raise biomarkers of inflammation (e.g., C-reactive protein, tumor necrosis factor receptors)

Trans Fats

- Trans fat intake should be less than 1% total calories
  - 2 g trans fat in a 2000-calorie diet

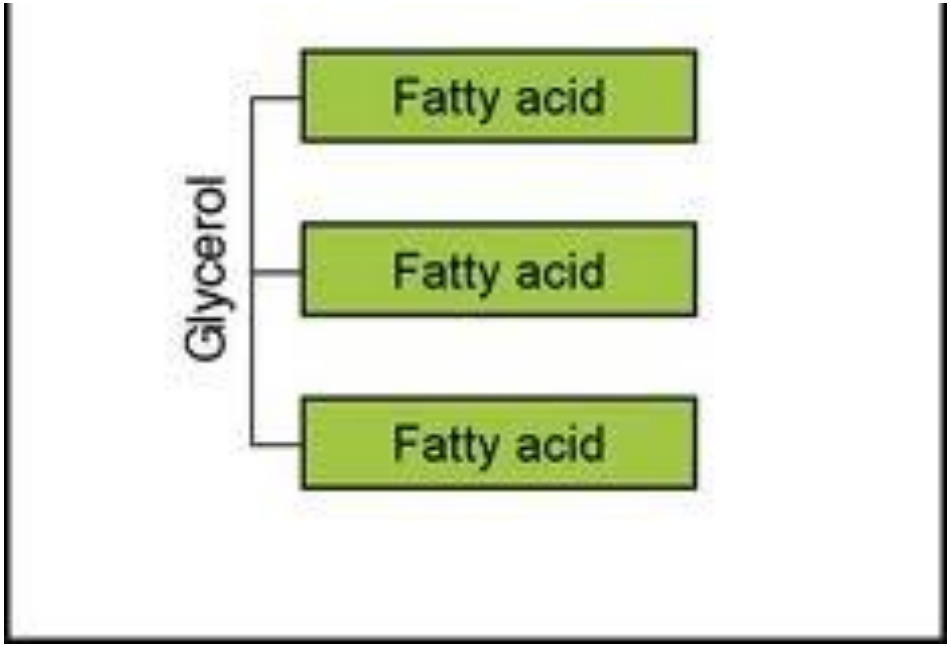
- French fries, stick margarine, shortening, potato chips, baked goods, and crackers.

Classes of Lipids

1. Triglycerides
   - fats and oils
2. Phospholipids
   - e.g., lecithin
3. Sterols
   - e.g., cholesterol

Triglycerides

- Composed of a **glycerol** molecule as its backbone with **three fatty acids** attached.
- Approximately 98% of the fat in foods is in the form of **triglycerides**



Functions of Triglycerides in the Body

1. Fuel the body
   - Certain cells, such as brain cells and cells of the central nervous system, normally rely solely on glucose for energy.
2. Fat deposits insulate and cushion internal organs to protect them from mechanical injury.

3. Fat under the skin helps to regulate body temperature by serving as a layer of insulation against the cold.

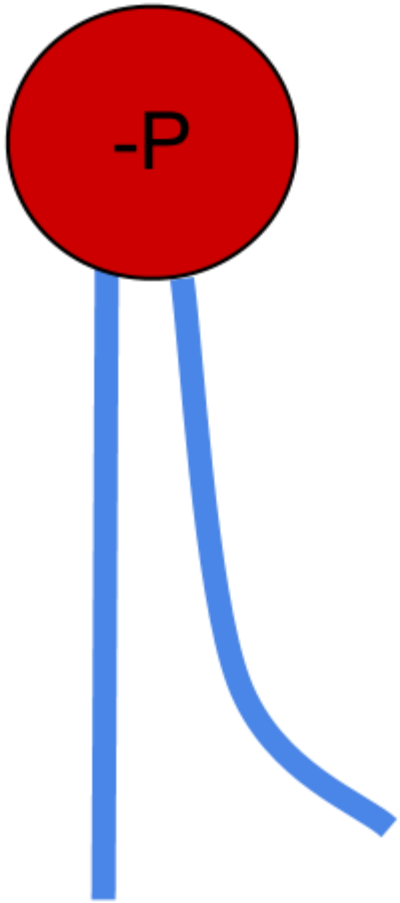
Functions of Triglycerides in the Body

4. Dietary fat facilitates the absorption of the fat-soluble vitamins A, D, E, and K when consumed at the same meal

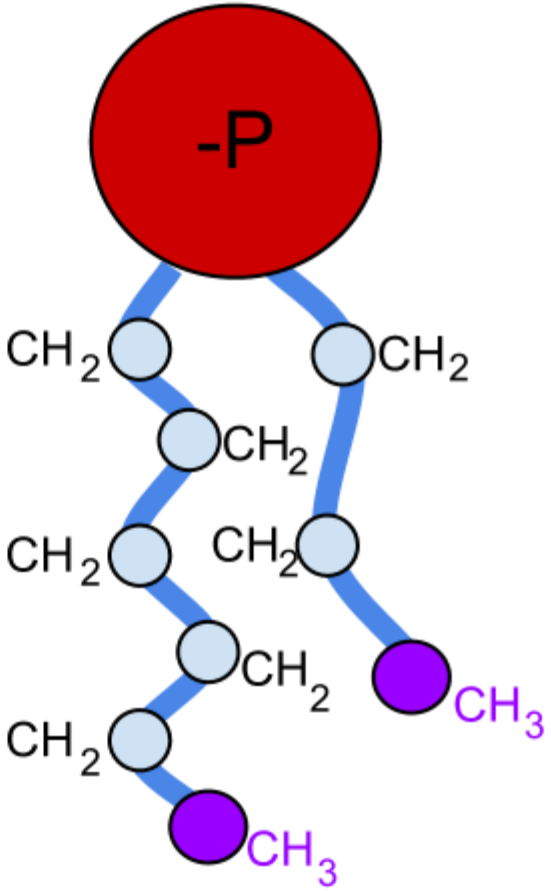
Phospholipids

- The other 2% of lipids in foods are phospholipids and sterols.

- a group of compound lipids that is similar to triglycerides in that they contain a glycerol molecule and two fatty acids. In place of the third fatty acid, phospholipids have a phosphate group



A phospholipid with a hydrophilic head and a hydrophobic tail



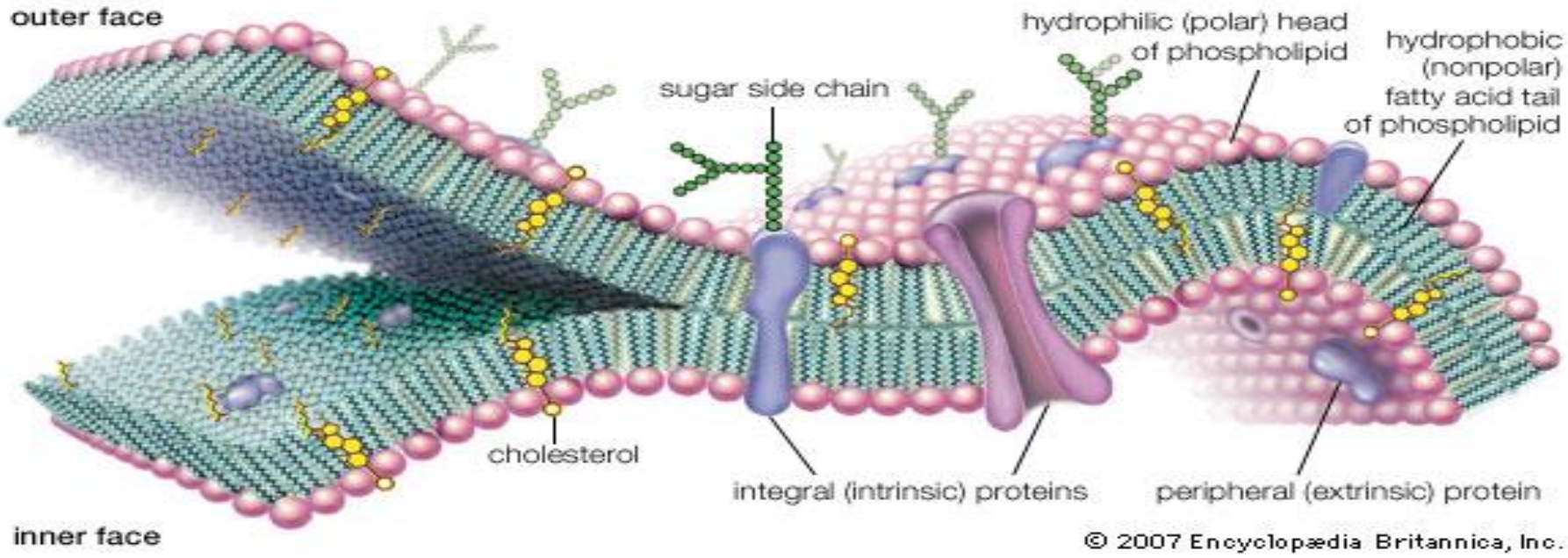
Chemical makeup of a single phospholipid

Phospholipids

- Are both fat-soluble (because of the fatty acids)
- And water-soluble (because of the phosphate group)
- a unique feature that enables them to act as **emulsifiers**

Phospholipids

- As a component of all cell membranes :
  - phospholipids provide structure
  - help to transport fat-soluble substances across cell membranes



Sterols : Cholesterol

- Cholesterol occurs in the tissues of all animals.

- The body synthesizes from cholesterol :
  - bile acids
  - steroid hormones
  - vitamin D

Sterols : Cholesterol

- Cholesterol is found exclusively in animals, with liver and egg yolks the richest sources.
- Its is not an essential nutrient
- Because all body cells are capable of making enough cholesterol to meet their needs.
- Daily endogenous cholesterol synthesis is approximately two to three times more than average cholesterol intake

Cholesterol

- When dietary cholesterol decreases, endogenous cholesterol production increases to maintain an adequate supply.

- Dietary cholesterol increases total and LDL cholesterol but the effect is lessened when saturated fat intake is low.

QUICK BITE

Cholesterol content of selected foods

	Cholesterol (mg)		*Cholesterol (mg)*
Beef brains, 3 oz	1746	Shrimp, 4	37
Beef liver, 3 oz	375	Whole milk, 1 cup	30
Beef kidney, 3 oz	329	2% milk, 1 cup	15
Egg yolk, 1	213	Butter, 1 tbsp	12
Broiled lobster, 1 cup	110	Nonfat milk, 1 cup	7
Broiled steak, 4 oz	71	Egg whites	0

Fat catabolism

- triglycerides that are needed for energy are split into glycerol and fatty acids by lipoprotein lipase and are released into the bloodstream to be picked up by cells.

- The catabolism of fatty acids increases when carbohydrate intake is inadequate

Fat Anabolism

- Most newly absorbed fatty acids recombine with glycerol to form triglycerides that end up stored in adipose tissue

- Adipose cells have a virtually limitless capacity to store fat and carry very little additional weight as intracellular water.

Fat anabolism

- fat reserves can last up to 2 months in people of normal weight.
- Each pound of body fat provides 3500 calories.

Fats in foods

- Milk
- Meats and beans
- Oils

- Other “fat free” groups :
  - **Fruits** : except for olives, avocado, coconut
  - **Vegetables**: except for fried, creamed, served with cheese
  - **Grains** : except for cereals, waffles …

QUICK BITE

Added fats add up

	Fat (g)		*Fat (g)*
Boiled potato, ½ cup	trace	French fries, 10	8
Mashed potatoes, ½ cup	4.4	Potato salad, ½ cup	10.3
Scalloped potatoes, ½ cup	4.5	Homemade hash browns, ½ cup	10.8

QUICK BITE

Grains with added fat

	g fat/serving
Apple cinnamon granola, 1 cup	19 g
Plain croissants, 1	17 g
Dry crispy chow mein noodles, 2 oz	16 g
Lemon poppy seed muffin, 1	13 g
Cheese crackers, 1 oz	7 g

The only fruits with natural fat

	Fat (g)	*Saturated fat (g)*
Avocado, 1 medium	15	2.3
Coconut, 2 tbsp shredded	4.0	4.0
Coconut milk, 1 cup	48.2	42.7
Olives (green or ripe), 5 large	3.0	0.5

1. Milk

- Full-fat
- Reduced fat
- Fat free

- Predominately saturated fats
- Full-fat products have more cholesterol than in the lower-fat options.

1. Milk

List and Representative Foods	Serving Sizes	CHO (g)	Protein (g)	Fat (g)
Milk				
Fat-free and low-fat milk and yogurt	1 cup milk; ⅔ cup plain or artificially sweetened yogurt	12	8	0–3
Reduced-fat milk and yogurt	1 cup milk; ⅔ cup plain yogurt	12	8	5
Whole milk and yogurt	1 cup milk; 8 oz yogurt	12	8	8

2. Meat and Beans

- Four subgroups based on fat content:

QUICK BITE

Examples of meat and beans by fat content

Very lean meats: 0–1 g fat per ounce
- Skinless, white meat chicken and turkey
- Scallops, shrimp, and tuna canned in water
- Egg whites, egg substitutes
- Dried peas, beans, and lentils

Lean meats: 3 g fat per ounce
- Lean beef
- Salmon
- Lean pork

Medium fat meats: 5 g fat per ounce
- Ground beef
- Prime rib
- Fried fish
- Dark meat chicken
- Egg yolk

High fat meats: 8 g of fat per ounce
- Pork sausage
- Bologna
- Bacon
- Peanut butter

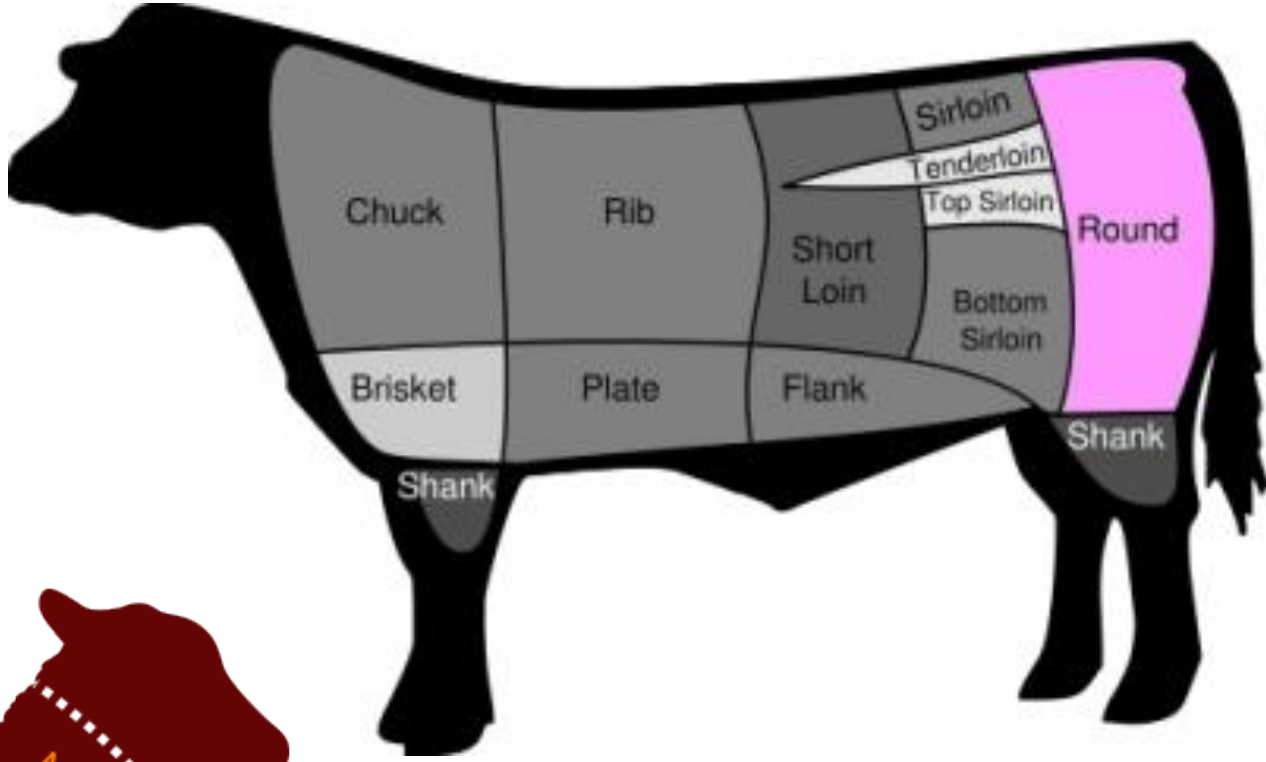
lean meats

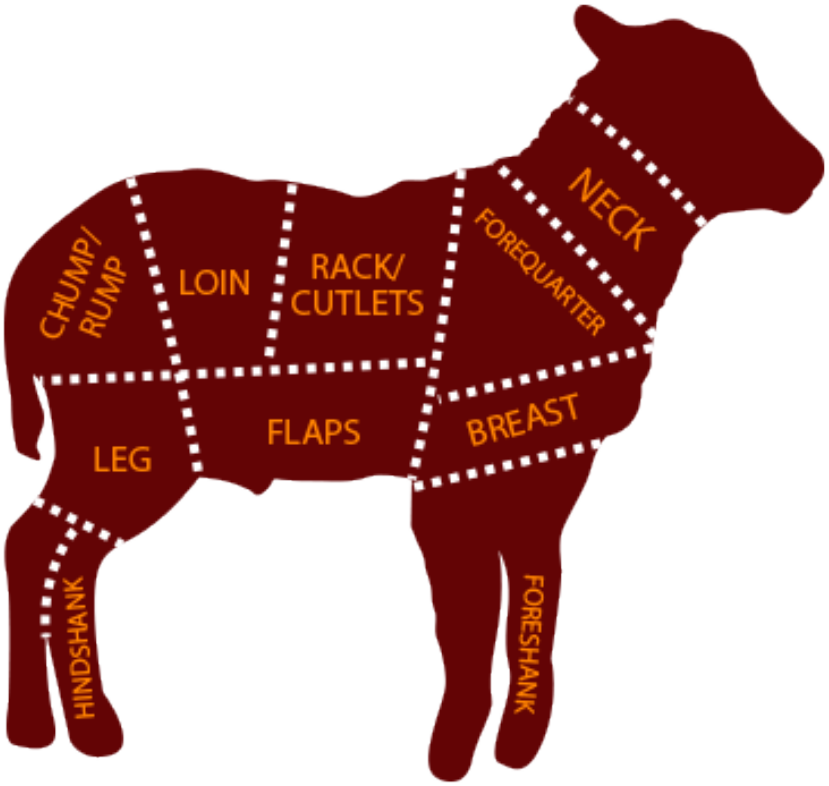
2. Meats and beans

Higher	Lower
Red meats (beef, pork, and lamb)	White meats (poultry)
Poultry with skin	Poultry without skin
Untrimmed meat	Lean portions of meat

2. Meats and Beans

- Fat content varies among different cuts of meat.
- The leanest cuts are:
  - beef loin and round
  - veal and lamb from the loin or leg


Chuck
Rib
Short Loin
Sirloin
Tenderloin
Top Sirloin
Round
Bottom Sirloin
Brisket
Plate
Flank
Shank
Shank


CHUMP/ RUMP
LOIN
RACK/ CUTLETS
NECK
FOREQUARTER
LEG
FLAPS
BREAST
HINDSHANK
FORESHANK

2. Meats and Beans

- Shellfish are very low in fat but have considerable cholesterol.

- Processed meats, such as sausage and hot dogs, **may provide more fat calories than protein calories**.

2. Meats and Beans

- Nuts have many healthy attributes; they contain plant protein, fiber, vitamin E, selenium, magnesium, zinc, phosphorus potassium.

- Their high fat content of 13 to 20 g/oz comes mostly from monounsaturated fats and polyunsaturated fats.

3. Oils

- Allowances are small : usually 5 to 7 teaspoons/ day for adults , depending on their total calorie needs.

- Include:
  - vegetable oils like canola, corn, and olive
  - oil-rich foods such as margarine and mayonnaise
  - avocado and nuts

How much is needed ??

Saturated fatty acids, monounsaturated fatty acids, and cholesterol **do not need to be consumed through food** !

Total Fat

- insufficient data to define a level of total fat intake at which risk of deficiency or prevention of chronic disease occurs

- (AMDR) is estimated to be **20% to 35% of total calories for adults**

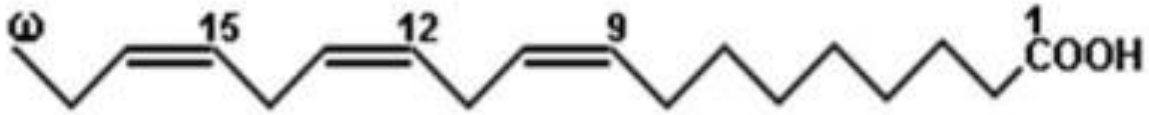
Saturated and Trans Fat

- should be as low as possible within the context of a nutritionally adequate diet.

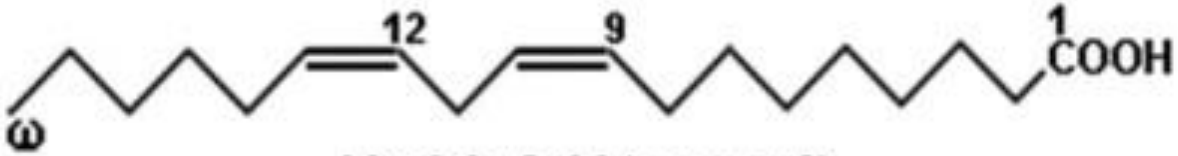
- Neither of these fats need to be consumed in the diet !!!

Essential Fatty Acid Deficiency

- Although the body cannot make essential fatty acids, it does store them
- Making deficiencies extremely rare in people eating a mixed diet.



Alpha-Linolenic Acid (omega-3)



Linoleic Acid (omega-6)

Essential Fatty Acid Deficiency

- Those **at risk** for deficiency include:
  - infants and children consuming low-fat diets (their need for essential fatty acids is proportionately higher than that of adults)
  - Clients with anorexia nervosa
  - People receiving lipid-free parenteral nutrition for long periods.
  - People with fat malabsorption syndromes

Essential Fatty Acid Deficiency

- Symptoms of essential fatty acid deficiency include:
  - –Growth failure
  - –Reproductive failure
  - –Scaly dermatitis
  - –kidney and liver disorders.

Cholesterol

Like saturated fats ,, intake should be as low as possible while consuming a nutritionally adequate diet.

FAT IN HEALTH PROMOTION

- Recently ,, **TYPE** of fat rather than **AMOUNT**
- **Eat Less Saturated Fat and Keep Trans Fat Consumption as Low as Possible**
- **Limit Total Fat and Go for Unsaturated Fats**

BOX 4.3 STRATEGIES FOR REDUCING AND MODIFYING FAT INTAKE

Eat Less Meat

- Eat occasional meatless meals like bean burritos, meatless chilli, vegetable soup with salad, spaghetti with plain sauce.
- Limit meat to 5 oz/day, a recommended portion is size of a deck of cards or smaller.

Eat Lean Meats

- Eat meat, fish, and poultry that are baked, broiled, or roasted instead of fried.
- Remove the skin from chicken before eating.
- Choose "select" grades of beef, which have less marbling than "choice" grades.
- Trim all visible fat from meat.
- Choose ground beef that is at least 90% lean as indicated on the label.
- Choose beef cuts labeled "loin" or "round."
- Limit egg yolks to two per week.

Substitute Low-Fat or Nonfat for Regular Varieties

- Use 1% or nonfat milk.
- Use low-fat or nonfat yogurt.
- Choose cheese with 3 g or less per serving.
- Try sherbet, reduced fat ice cream, nonfat ice cream, and yogurt.
- Try low-fat or nonfat salad dressing.
- Use nonstick spray in place of oil, margarine, or butter to sauté foods and "butter" pans.
- Use imitation butter spray to season vegetables and hot air popcorn.

Limit Fat as a Flavoring

- Eat bread, rolls, muffins, or crackers without butter or margarine.
- Season with spice such as picante sauce, salsa, ginger, flavored vinegar, Italian spice blends.
- Eat potatoes and vegetables that are not fried.
- Instead of pouring dressing on salad, have it on the side; dip your fork into the dressing before spearing salad.
- Have desserts without cream or whipped cream toppings.

Reduce Hydrogenated Fat Intake

- Use the soft margarine (liquid or tub) in place of butter or stick margarine. Look for margarine that is "trans fat–free," contains no more than 2 g saturated fat/tablespoon, and has liquid vegetable oil as the first ingredient.
- Look for processed foods made with unhydrogenated oil rather than hydrogenated or saturated fat.
- Avoid French fries, doughnuts, cookies, and crackers unless they are labeled fat free.
- Avoid fried fast foods that are made with hydrogenated shortenings and oils.

Replace Fatty Foods With Fruit and Vegetables

- Eat fruit for dessert.
- Snack on raw vegetables or fresh fruit instead of snack chips.
- Double up on your usual portion of vegetables.

Use "Good" Fats in Moderation

- Make canola or olive oil your oil of choice.
- Eat fatty fish twice a week.
- Eat nuts and nut butters that are rich in monounsaturated fats: walnuts, almonds, hazelnuts, pecans, pistachios, and pine nuts. Walnuts also contain alpha-linolenic acid. Cashews and macadamia nuts are higher in saturated fats.
- Sprinkle flaxseed (1–2 tablespoons/day) over cereal or yogurt or use as a fat substitute in many recipes: 3 tablespoons of ground flaxseed can replace 1 tablespoon fat or oil.

Fish Oil

- Recommendation for healthy people to eat at least two servings of fish per week, preferably **fatty fish**

- This recommendation is based on the assumption that 12 ounces of fatty fish per week averages out to approximately 500 mg/day of EPA and DHA, the amount recommended to reduce the risk of heart disease.

QUICK BITE

The content of fish oils in selected foods

Item (6 oz portion unless otherwise indicated)	*Amount of DHA + EPA (mg)*
Atlantic salmon, farmed	3650
Atlantic salmon, wild	3130
Rainbow trout, farmed	1960
Swordfish	1390
Flounder	850
Sole	850
Scallops	620
Yellow fish tuna, fresh	560
Catfish, wild	400
Lobster (3 oz)	70
Egg (1 large)	20

For people who do not eat seafood, fish oil pills are an alternative source of omega-3 fats (Gebauer et al., 2006) but they have drawbacks (Box 4.4). A wide variety of products with added "omega-3s" or "DHA" are available, such as mayonnaise, margarine, eggs, cereal, milk, yogurt, and even puppy dog food. But beware: many products have alpha-linolenic acid added as the source of omega-3. While it is true that alpha-linolenic acid is an omega-3 fatty acid, it has not been shown to be protective against heart disease or any of the other

BOX 4.4 POTENTIAL DRAWBACKS OF FISH OIL SUPPLEMENTS

- They prolong bleeding time. People taking anticoagulants and those with clotting abnormalities should be monitored while using fish oil supplements.
- Doses more than 3 g/day may suppress immune system function and may increase the risk of hemorrhagic stroke.
- Although most fish oil supplements do not contain vitamin A, those from shark and halibut liver oils contain high levels and they should not be used by pregnant women.
- Fish oils are susceptible to rancidity and should be stored in the refrigerator.

Source: Fragakis, A. and Thomson, C. (2007). The health professional's guide to popular dietary supplements (3rd ed.). Chicago, IL: The American Dietetic Association.