

Nutrition and Diet Therapy

Chapter 4: Lipids



Learning Objectives

- Identify the major roles of fat in the body.
- Compare the chemical makeup and physical properties of saturated fats, monounsaturated fats, polyunsaturated fats, phospholipids, and sterols.
- Summarize fat digestion and absorption.
- Explain the relationships among saturated fats, *trans* fat, cholesterol, monounsaturated and polyunsaturated fats, and chronic diseases, noting recommendations.

Learning Objectives

- Identify the roles of fats in foods and list sources of solid fats and unsaturated fats.
- Identify which fats support health and which may impair it.

Introduction to Lipids

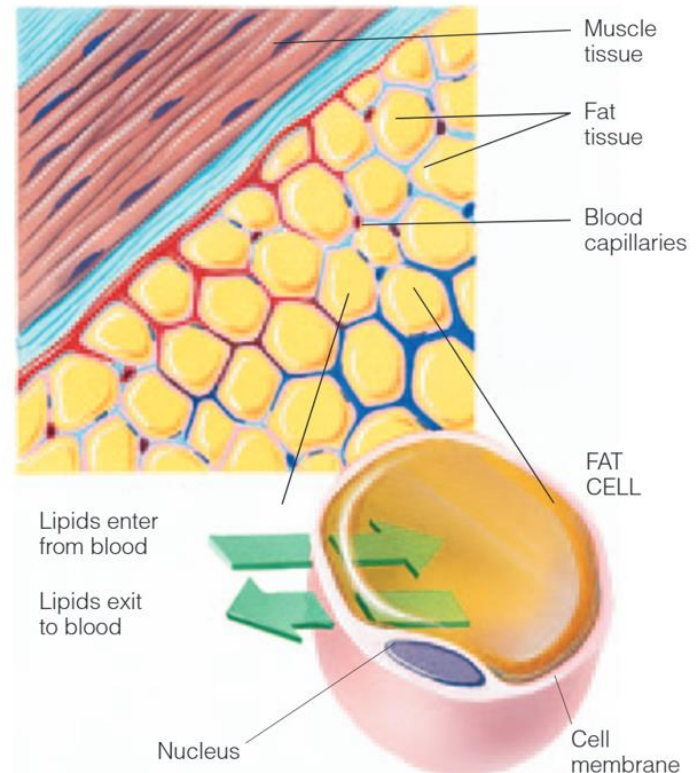
- Too much/too little fat in diet → health risks
- Fat is member of group of compounds called **Lipids**:
 - Provide energy
 - Found in foods and the body:
 - Triglycerides (fats & oils)
 - Phospholipids
 - Sterols (cholesterol)

Energy from Fat

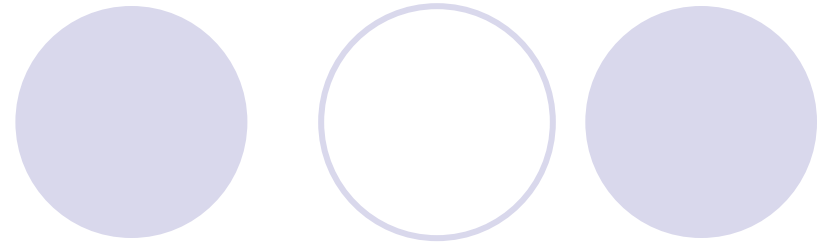
- Fat stored in adipose tissue
 - Store indefinite amount of fat here
 - Cannot reduce the number of fat cells (only shrink them)
- Contribute ~60% of energy needs during rest

FIGURE 4-3 Three Types of Fatty Acids

Within the fat or adipose, cell, lipid is stored in a droplet. This droplet can greatly enlarge, and the fat cell membrane will expand to accommodate its swollen contents.



Roles of Body Fat



- Provides a healthy complexion
- Help nourish scalp & hair and give it “glossy” appearance
- Insulates body from extreme temperatures
- Protects vital organs
- Maintain structure & health of cells (part of cell membranes)

Roles of Body Fat

TABLE 4-1 The Functions of Fats In the Body

- *Energy stores.* Fats are the body's chief form of stored energy.
- *Muscle fuel.* Fats provide much of the energy to fuel muscular work.
- *Padding.* Fat pads inside the body cavity protect the internal organs from shock.
- *Insulation.* Fats insulate against temperature extremes by forming a fat layer under the skin.
- *Cell membranes.* Fats form the major material of cell membranes.
- *Raw materials.* Fats are converted to other compounds, such as hormones, bile, and vitamin D, as needed.

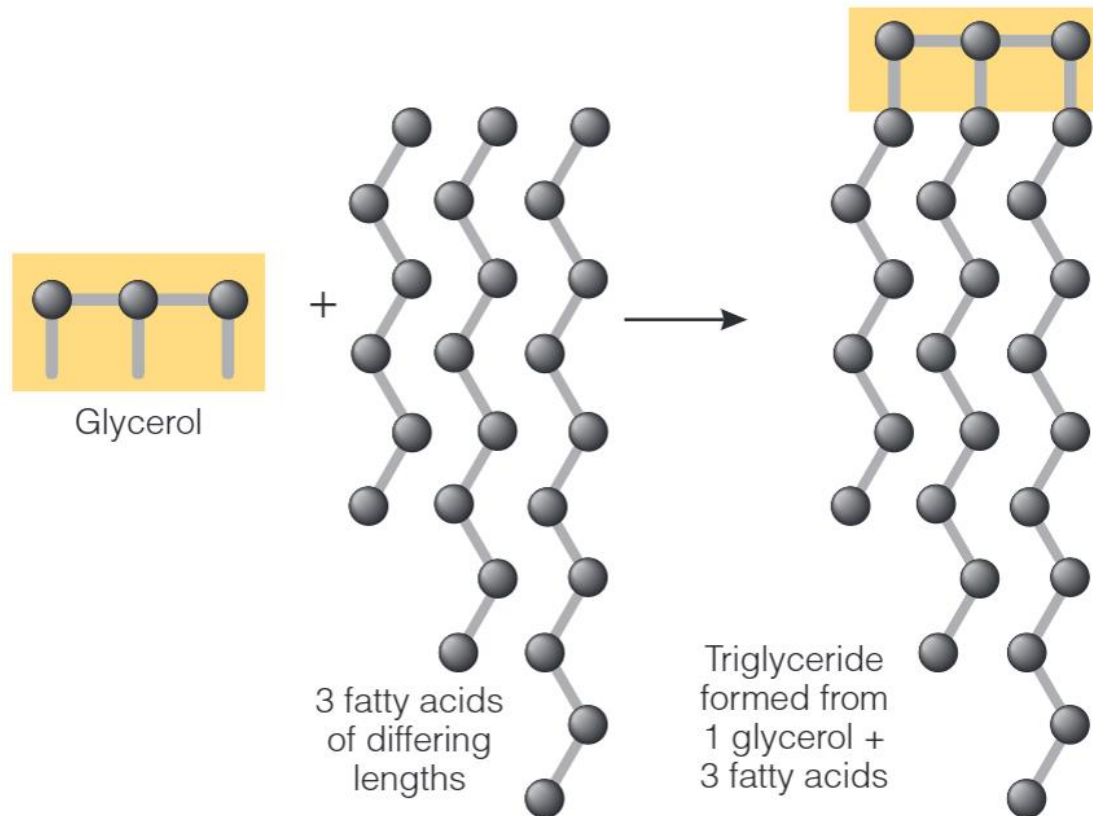
The Chemist's View

- **Triglycerides:**
- One of the main classes of lipids
- “I’m too **fat**” or “that meat is **fatty**”
- Most predominant lipid in body and in foods we eat (major storage form of fat in body)
- Three fatty acids (*tri*) attached to a glycerol “backbone”

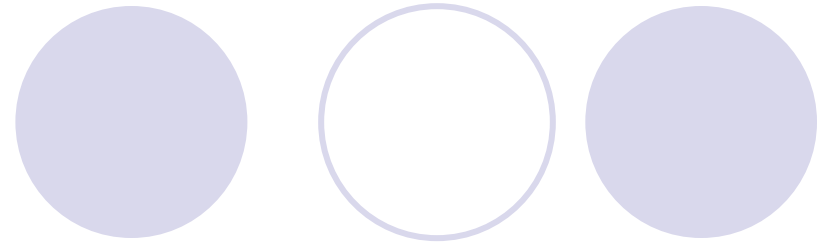
The Chemist's View

FIGURE 4-2 Triglyceride Formation

Glycerol, a small, water-soluble compound plus three fatty acids equals a triglyceride.



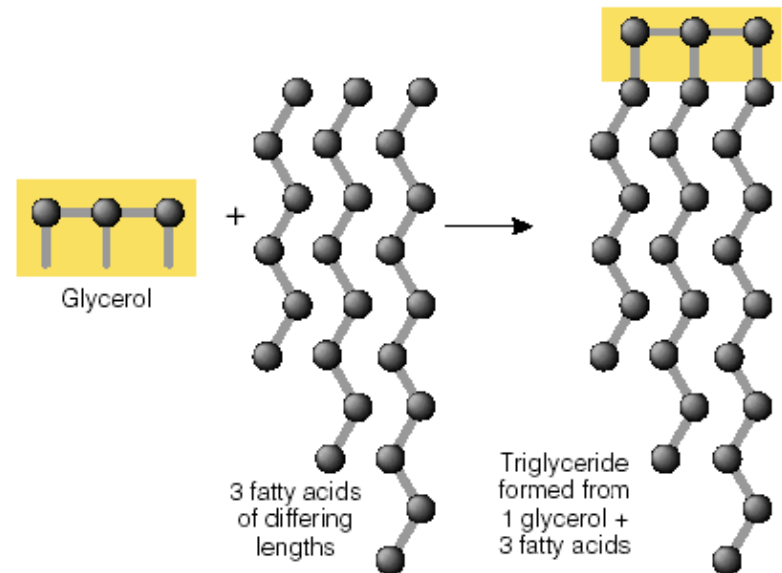
Chemist's View



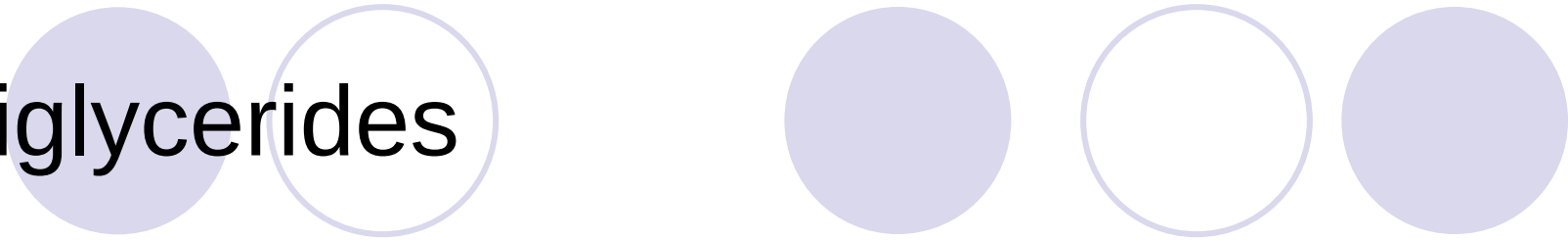
- Triglycerides

- Formation

- Body breaks down nutrients into small fragments
- Uses some energy and stores the rest
- Fragments are put back together in chains (fatty acids)
- Fatty acids are packaged (3 at a time) with glycerol

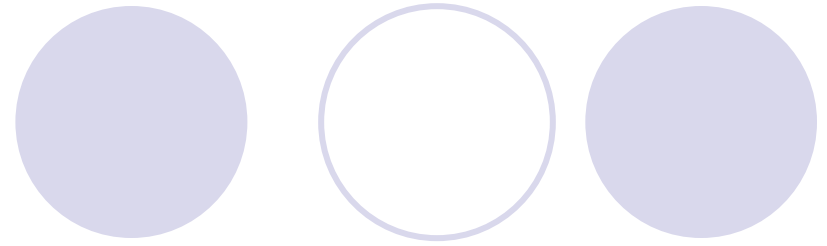


Triglycerides



- Fatty acids differ in two ways:
- **Chain length:**
 - # of carbons in a fatty acid
- **Degree of saturation:**
 - # of hydrogen molecules the carbons are holding

Triglycerides

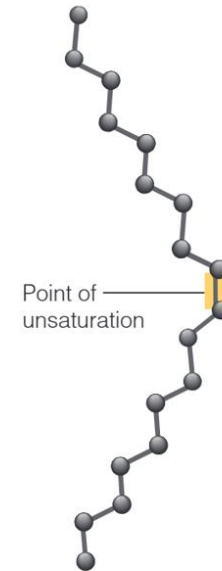


- Saturated Fatty Acid:
 - Every available bond filled with hydrogen
 - Only **single bonds** between carbons
- Unsaturated Fatty Acid:
 - Hydrogens are missing in fatty acid chain
 - “points of unsaturation”
 - At least one **double bond** between carbons
 - One point of unsaturation = monounsaturated fatty acid (MUFA)
 - Two or more points of unsaturation = polyunsaturated fatty acid (PUFA)

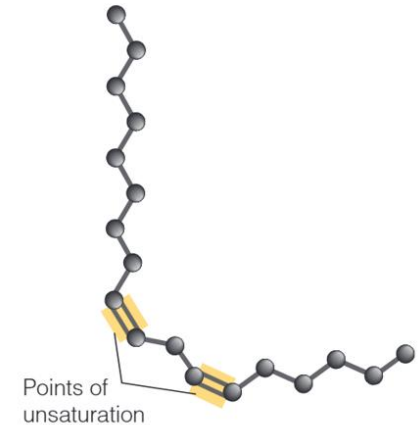
Saturated



Monounsaturated



Polyunsaturated



Triglycerides

FIGURE 4-3 Three Types of Fatty Acids

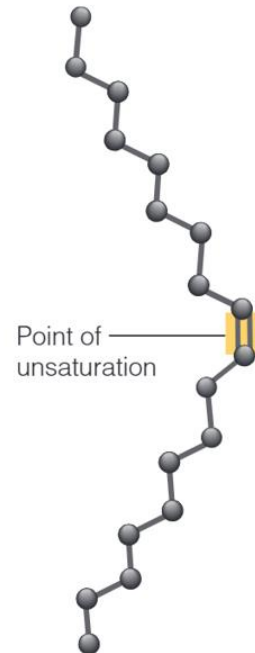
The more carbon atoms in a fatty acid, the longer it is.

The more hydrogen atoms attached to those carbons, the more saturated the fatty acid is.

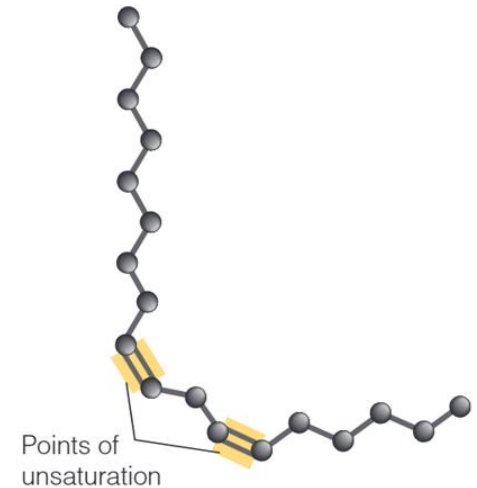
Saturated



Monounsaturated



Polyunsaturated



Triglycerides

- Hard vs. Soft fat:

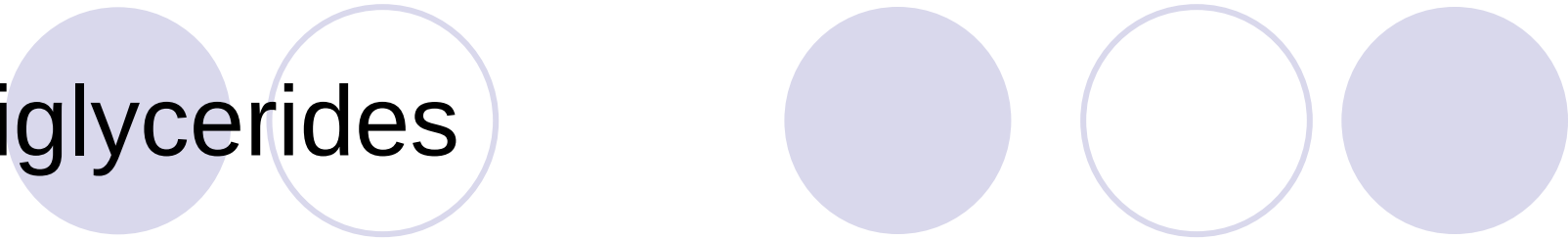
- The shorter the chain and the more unsaturated
= softer at room temperature

- Lard is solid at room temperature and more saturated

- Safflower oil is liquid at room temperature and is more unsaturated



Triglycerides

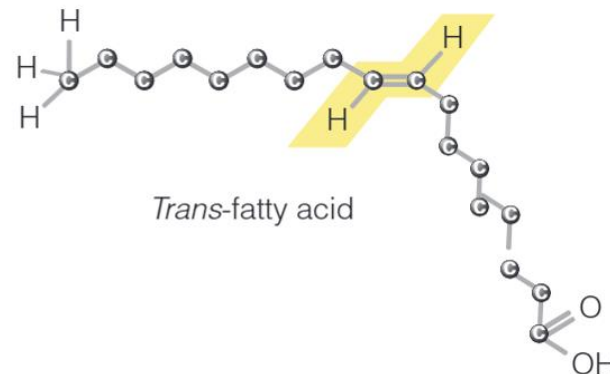
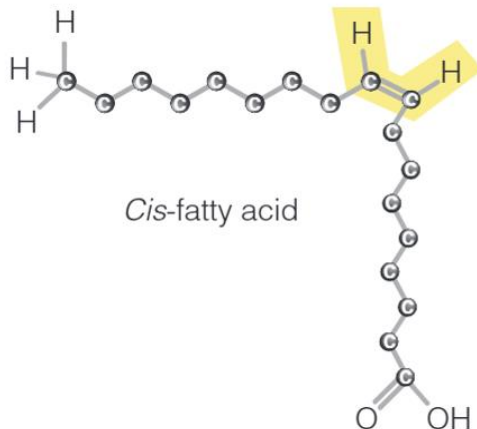


- Stability:

- When exposed to oxygen, fats become rancid
 - PUFA go rancid faster
 - Unsaturated fats go rancid faster
- Rancid food has an “off” odor
- Protection from rancidity
 - Air-tight and refrigerated
 - Antioxidants
 - Hydrogenation (reduces # of double bonds)
 - Prolongs shelf life and alters texture
 - Makes PUFA more saturated
 - Looses the health benefits of PUFA's
 - Produces trans fatty acids

Trans-Fatty Acids

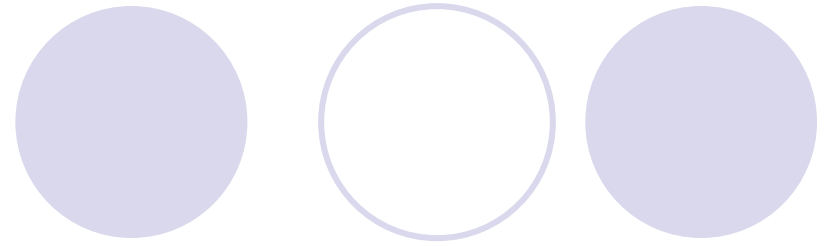
- Result from hydrogenation
- *Cis*
 - Hydrogens next to the double bond are on the **same side** of carbon chain
- *Trans*
 - Hydrogens next to the double bond are on opposite sides
 - Acts more like a saturated fatty acid in the body
 - Negative health effects (increased blood cholesterol & heart disease risk)



Essential Fatty Acids

- Body can make all the fatty acids it needs except for two:
 - **Linoleic and Linolenic:**
 - PUFA
 - Essential
 - Found in plant oils
 - Readily stored in body
 - Many body functions
 - Structural components of cell membranes
 - **Linoleic:**
 - Omega 6 FA
 - Plant seeds and oils, vegetable oils, seeds, nuts, whole grains
 - **Linolenic:**
 - Omega 3 fatty acid (EPA and DHA)
 - Body can make EPA & DHA with sufficient linolenic
 - Mainly in fish oils
 - Recommendations
 - Our diet is high in Omega 6 (vegetable cooking oils) and low in Omega 3
 - 2 servings of fish per week

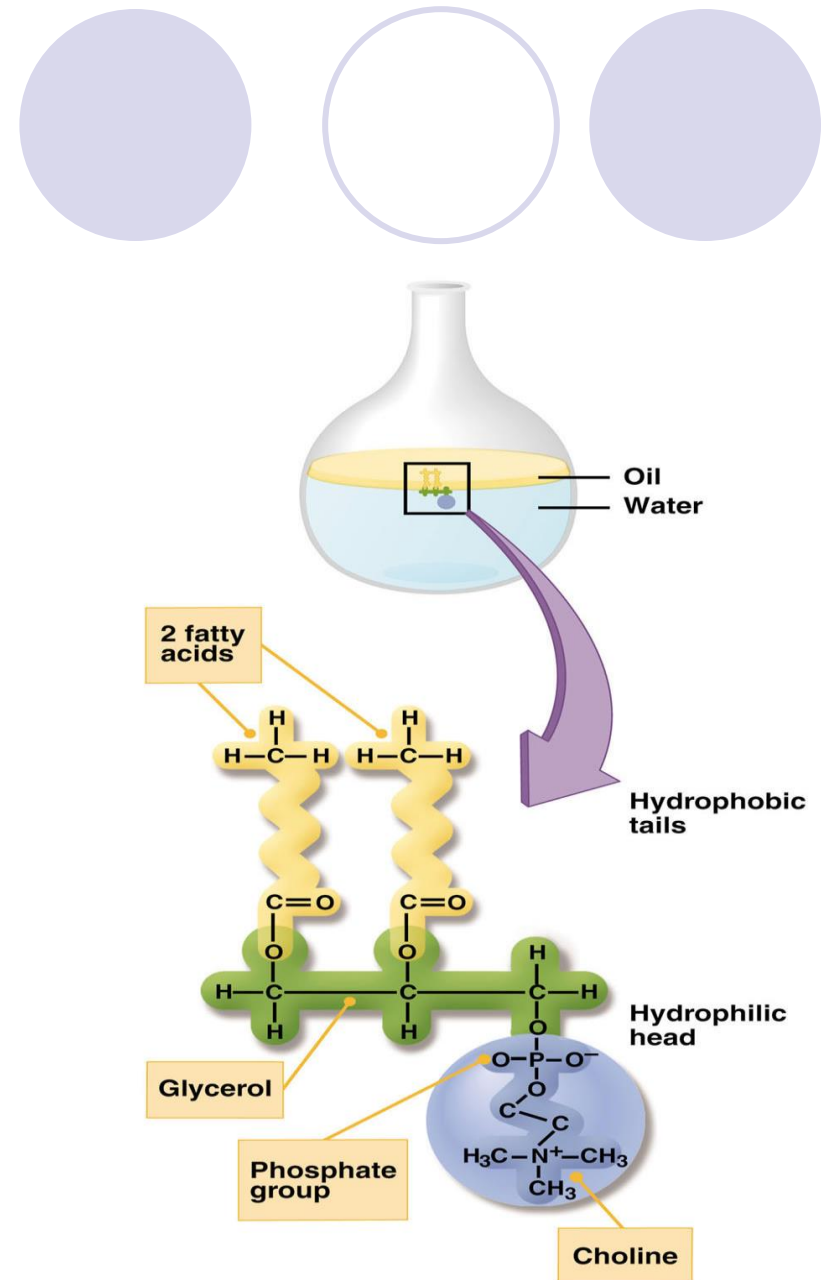
Phospholipids



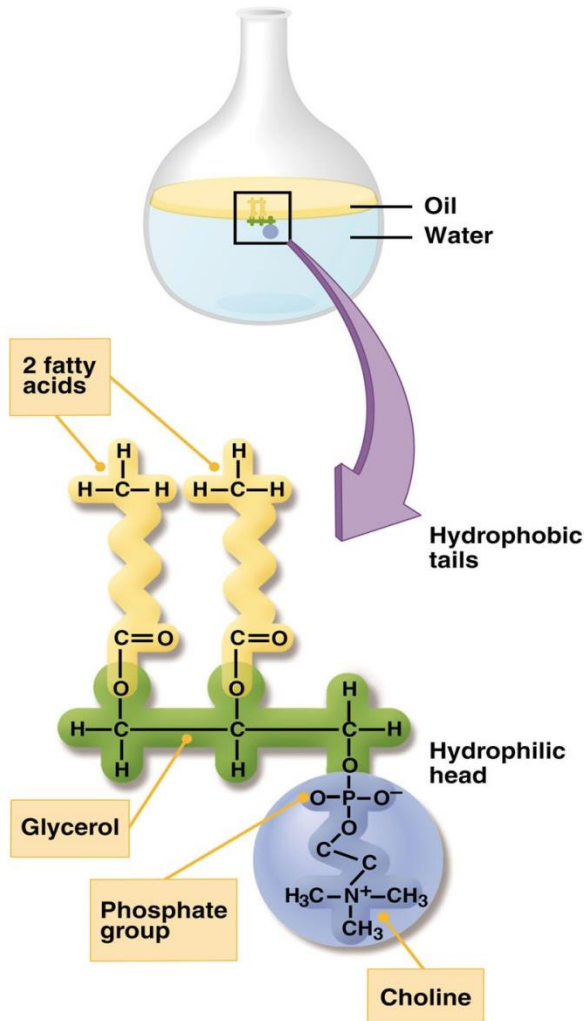
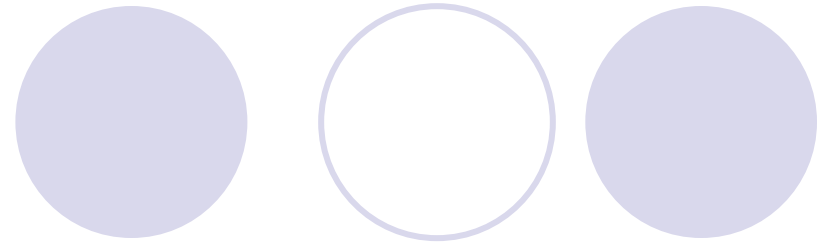
- Another class of lipids
- Only 5% of lipids in diet
- Structure:
 - Backbone of glycerol
 - Only 2 fatty acids attached to glycerol
 - Phosphate group & molecule of choline
- Ex.-Lecithin

Phospholipids

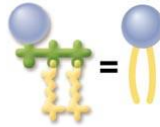
- Fatty acids: soluble fat
- Phosphate group: enables phospholipids to dissolve in water
- Used by food industry as **emulsifiers**
 - Used to make mayo
- Also act as emulsifiers in the body
 - Keep fat in blood
- Found in eggs, liver, soybeans, wheat germ, and peanuts



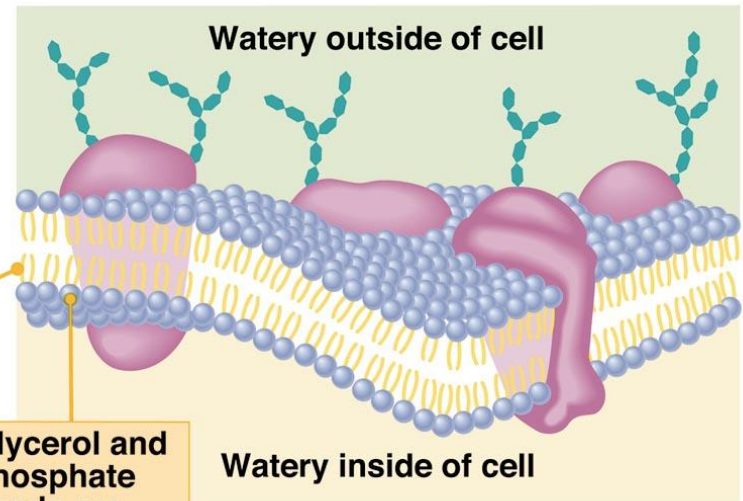
Phospholipids



Key



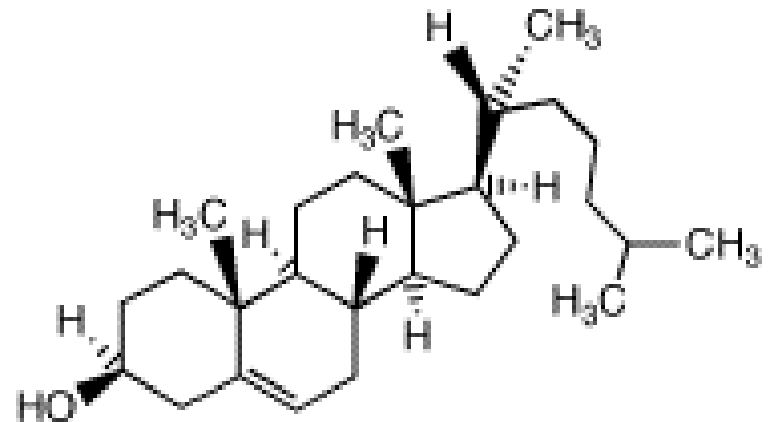
Fatty acid tails orient themselves away from watery fluids



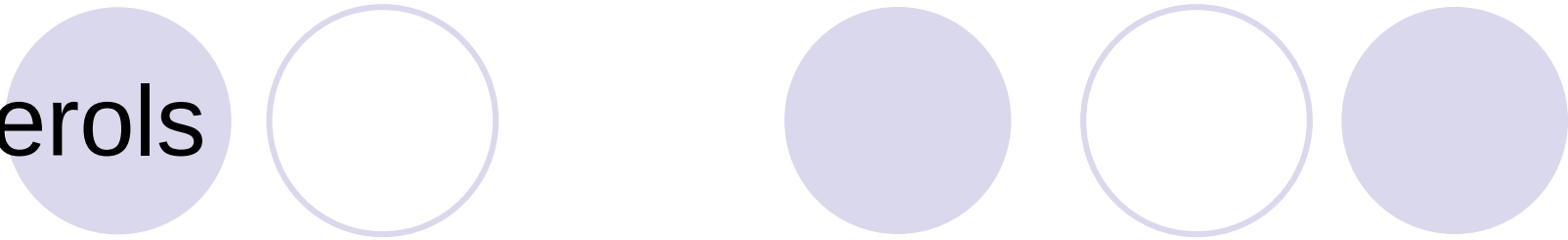
Glycerol and phosphate heads are attracted to watery fluid

Sterols

- Another of the three main classes of lipids
- Large, complex molecules
- Cholesterol (most familiar sterol)
- Other include: Vitamin D, sex hormones (testosterone)
- In food:
 - Plant and animal derived foods
 - Only animal derived foods contain cholesterol
 - Meat, eggs, fish, poultry, dairy, organ meats



Sterols



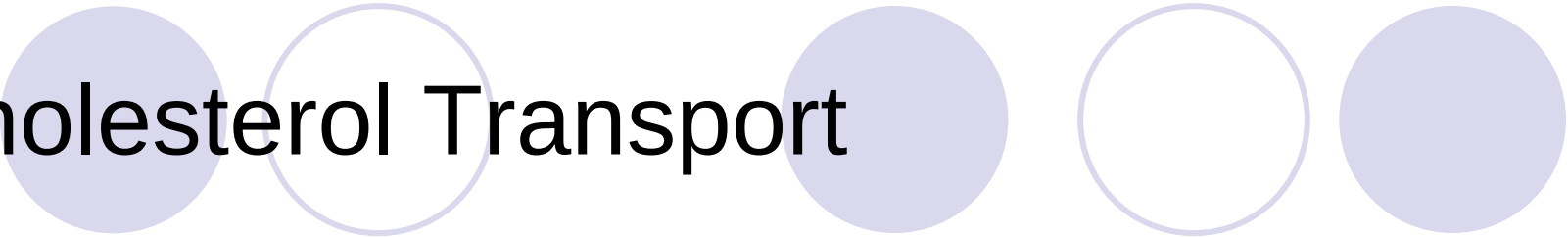
- Synthesis of Cholesterol

- Can be made by the body
 - Nonessential
- Made from carbohydrate, protein, or fat
- Made by the liver
- Found in cell membranes
- Provides structural and metabolic functions

Cholesterol's Route in the Body

- Incorporated into bile, stored in gallbladder and delivered to intestine
- Transported to all body cells via the bloodstream
- Some bile trapped in soluble fibers or by medications, then excreted in feces
 - Reduces total remaining cholesterol in body

Cholesterol Transport



- Packaged with other lipids and proteins (**lipoproteins**)
- Tissues can extract lipids from lipoproteins as they travel through the body
- Can be harmful when it forms deposits in arterial walls
 - Contributes to atherosclerosis

Classes of Lipids (Summary)

Table 3–3 The Lipid Family

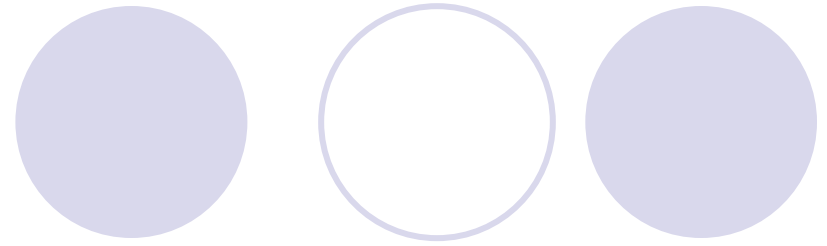
Triglycerides (fats and oils)

- Glycerol (1 per triglyceride)
- Fatty acids (3 per triglyceride)
 - Saturated
 - Monounsaturated
 - Polyunsaturated
 - Omega-6
 - Omega-3

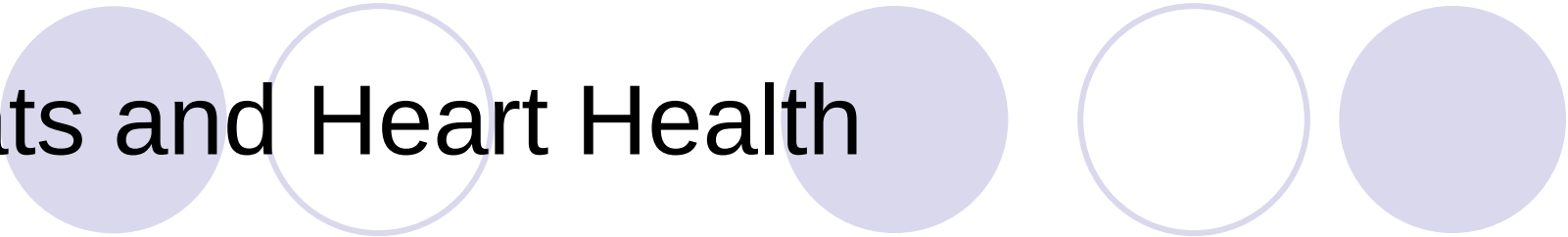
Phospholipids (such as the lecithins)

Sterols (such as cholesterol)

Fats and Health

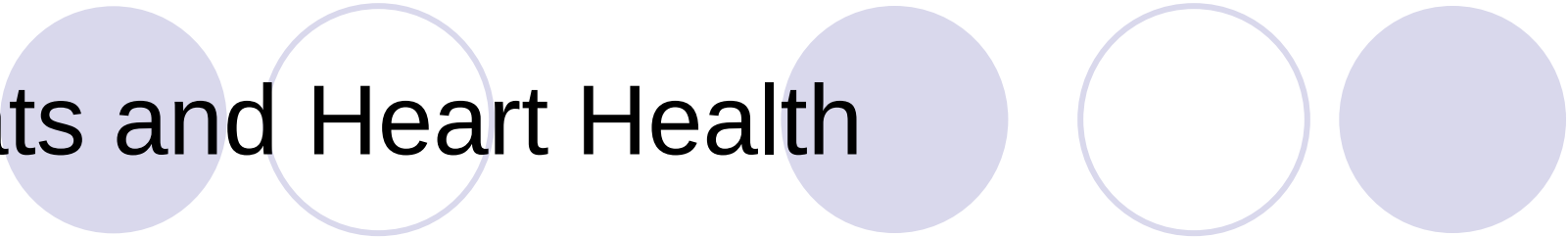


- Excessive intakes of dietary fat prevalent in developed countries & linked to many chronic diseases:
 - **atherosclerosis** (ath-er-oh-scler-OH-sis): a type of artery disease characterized by accumulations of lipid-containing material on the inner walls of the arteries.
 - **cardiovascular disease (CVD)**: a general term for all diseases of the heart and blood vessels.



Fats and Heart Health

- **Low-density lipoproteins (LDL) and high-density lipoproteins (HDL) play major roles**
 - High blood concentration of LDL increases risk of heart attack and stroke
 - Low blood concentration of HDL also increases disease risk
- Cholesterol in food not the main factor in raising blood cholesterol



Fats and Heart Health

Saturated Fats and Blood Cholesterol

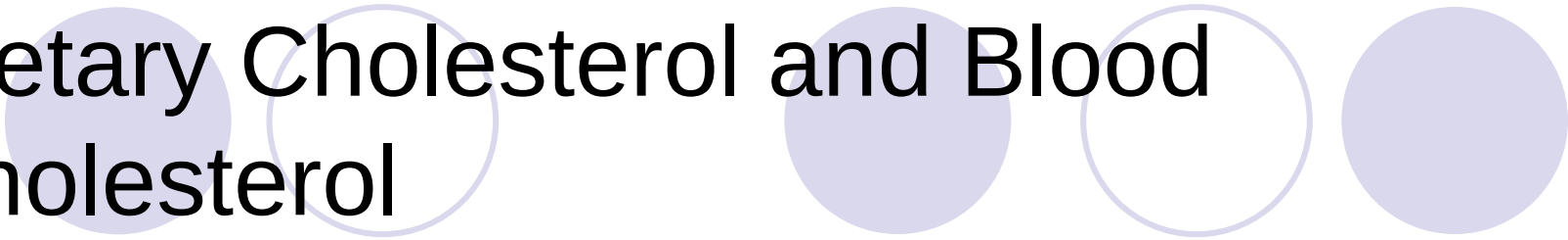
- High saturated fat and high *trans* fat intakes
 - Associated with elevated blood LDL levels
- Solid fats provide abundant saturated and *trans* fats
 - Fats from animal sources contribute greatly
- Dietary recommendation
 - Replace saturated fats with polyunsaturated and monounsaturated fats

Fats and Heart Health

- *Trans*-Fatty Acids:

- Commercially-derived *trans*-fatty acids increase LDL and lower HDL cholesterol
 - Results in inflammation
- Some margarines are formulated to contain less *trans*-fat
- Look for the words “hydrogenated vegetable oil” or “shortening” in the ingredient list (contain substantial *trans*-fat)

Dietary Cholesterol and Blood Cholesterol



- Dietary cholesterol seems to have little to no effect on blood cholesterol levels as once thought
 - Saturated fat & trans fat have greatest effect
- Highest cholesterol sources
 - Eggs, chicken, and beef

Monounsaturated Fatty Acids and Blood Cholesterol

- Replacing saturated and *trans*-fats with monounsaturated fats may help prevent heart disease
 - Example: olive oil
 - Olive oil delivers valuable phytochemicals

Polyunsaturated Fatty Acids, Blood Cholesterol, & Heart Disease Risk

- Polyunsaturated fatty acids of **omega-3** family
 - Potent protectors against heart disease
- EPA and DHA mechanisms to protect heart health
 - Lower blood triglycerides
 - Prevent blood clots and irregular heartbeats
 - Lower blood pressure
 - Defend against inflammation



TABLE 4-4 Major Sources of Various Lipids

Healthful Fatty Acids	
Monounsaturated	Avocado Oils (canola, olive, peanut, sesame) Nuts (almonds, cashews, filberts, hazelnuts, macademia nuts, peanuts, pecans, pistachios) Olives Peanut butter Seeds (sesame)
Omega-6 Polyunsaturated	Margarine (nonhydrogenated) Oils (corn, cottonseed, safflower, soybean) Nuts (pine nuts, walnuts) Mayonnaise Salad dressing Seeds (pumpkin, sunflower)
Omega-3 Polyunsaturated	Fatty fish (herring, mackerel, salmon, tuna) Flaxseed, chia seed Marine algae Nuts (walnuts) Oils (canola, flaxseed, soybean, walnuts) Yeast

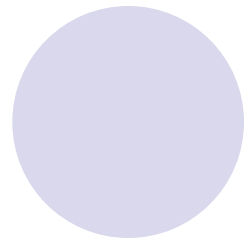
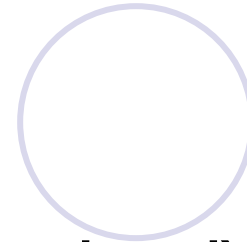
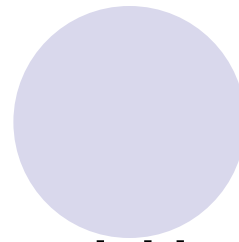
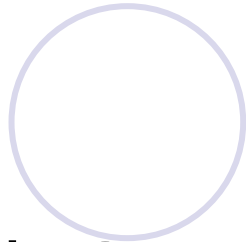
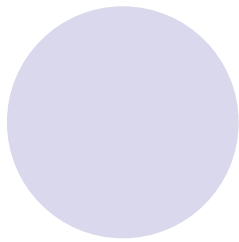


TABLE 4-4 Major Sources of Various Lipids, (continued)

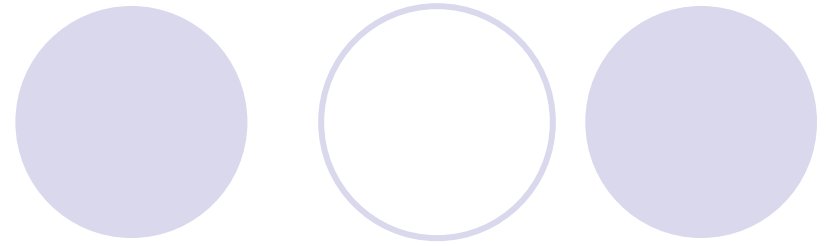
Harmful Fatty Acids	
Saturated Trans	Bacon, butter, lard Cheese, whole milk products Chocolate, coconut Cream, half-and-half, cream cheese, sour cream Meats Oil (coconut, palm, palm kernel Shortening
<i>Trans</i>	Fried foods (hydrogenated shortening) Margarine (hydrogenated or partially hydrogenated) Nondairy creamers Many fast foods Shortening Commercial baked goods (including doughnuts, cakes, cookies) Many snack foods (including microwave popcorn, chips, crackers)

What about Omega-3 Supplements?

- Fish is preferred source of omega-3
- Supplements pose health risks
 - Increase bleeding time
 - Raise LDL cholesterol
 - Suppress immune function
- Too much of a nutrient as harmful as too little



Fats and Health



- Recommendations:
 - Total fat: 20-35% of total kcals/day
 - Portion of each day's fat from raw oils
 - Examples of oils with different benefits: peanut, safflower, olive, canola, sunflower
 - 6 teaspoons total oil per day
- Diet low in saturated fat, *trans*-fat, and cholesterol
- Do not limit fat intake in children under age 2 years

Fats in Foods

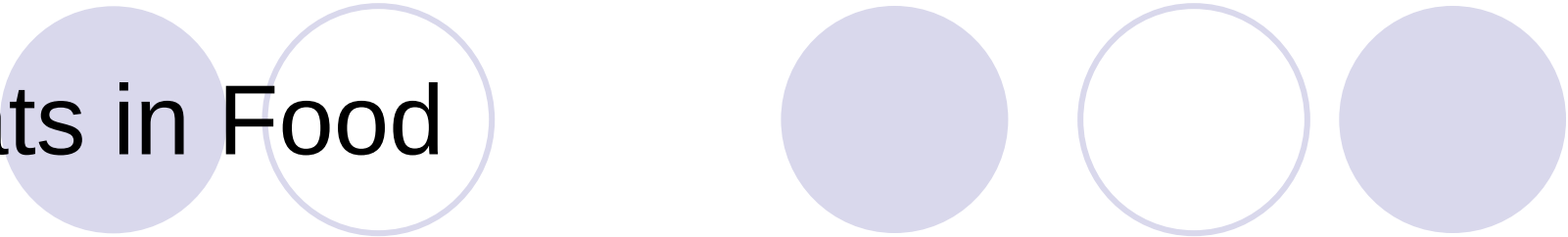
- Contribute flavor & aroma
- Influence texture of foods
- Help make food tender
- Vitamins : A, D, E, & K (fat-soluble)
- Give us essential fatty acids



Fats in Foods

TABLE 4-6 The Functions of Fats in Foods

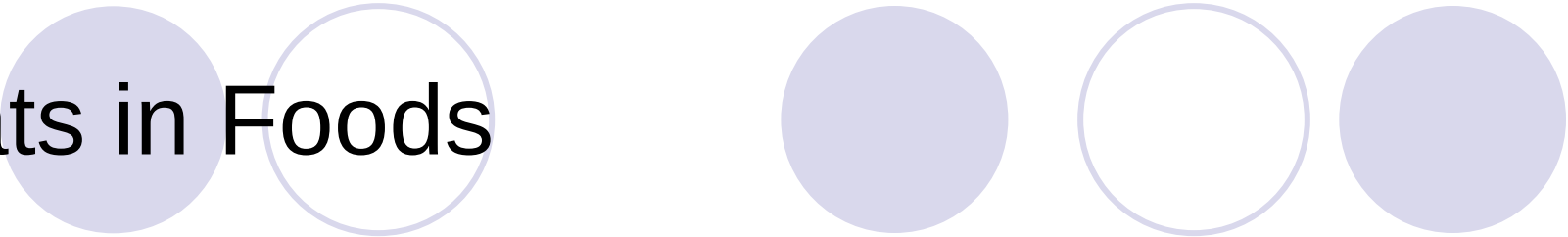
- *Nutrient.* Food fats provide essential fatty acids and other raw materials.
- *Energy.* Food fats provide a concentrated energy source.
- *Transport.* Fats carry fat-soluble vitamins A, D, E, and K, along with some phytochemicals, and assist in their absorption.
- *Sensory appeal.* Fats contribute to the taste and smell of foods.
- *Appetite.* Fats stimulate the appetite.
- *Satiety.* Fats contribute to feelings of fullness.
- *Texture.* Fats make fried foods crisp and other foods tender.



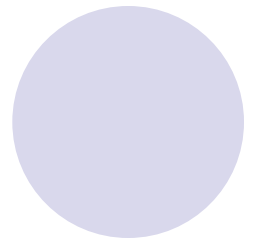
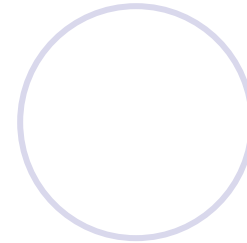
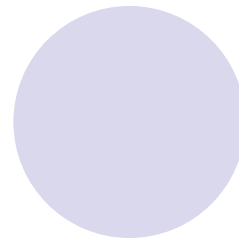
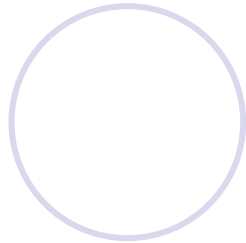
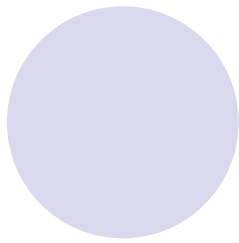
Fats in Food

- Important to know which foods are sources of unsaturated fats, essential fatty acids, and harmful fats
- Examples of foods containing five grams of fat
 - One teaspoon of oil or shortening
 - One and one-half teaspoon of mayonnaise, butter, or margarine
 - One tablespoon regular salad dressing

Fats in Foods



- Some fat readily apparent
 - Example: rim of fat on a steak
- Examples of foods with hidden fats
 - Biscuits
 - Cakes
 - Dips
 - Spreads
 - Ice cream
 - Fried foods



Finding the Fats in Foods

TABLE 4-7 Fat Options among Milk and Milk Products

Fat Classification	Milk and Milk Products
Fat-free and low-fat options	Fat-free (skim) or 1 % (low-fat) milk or yogurt (plain)
Reduced-fat options	2% milk or yogurt (plain)
High-fat options	Whole milk, yogurt, most cheeses

Fats in Foods

Protein Foods:

- Meat categories

- Lean

- Medium-fat

- High-fat

- All three categories contain about same protein content

- Fat, saturated fat, and kcalories differ greatly

- USDA Food Patterns recommendation

- Daily meat intake of five to seven ounces

Fats in Foods



Selecting Meats to Control Fat:

- Select loin or round cuts of beef or pork
 - Trim all visible fat
 - Eat smaller portions
- Chicken and turkey naturally lean
 - Avoid commercially processed and fried chicken and turkey

Fats in Foods

Vegetables, Fruits, and Grains:

- Vegetables and fruits contain little or no fat
 - Exceptions: avocados and olives contain unsaturated fat
- Refined grain products high in saturated fat
- Additional fat may be added during preparation or serving
- Abundant vitamin A, C, E, folate, and fiber
- Reducing fat and increasing nutrients and phytochemicals protects against disease

Fats in Foods

- Ways to Reduce Dietary Fat Intake:
 - Choose leaner meats: poultry, fish, and fat-free dairy products
 - Trim meats
 - Reduce fat-rich condiments like sour cream and butter
 - Olive oil and canola oil are rich in monounsaturated
 - Replace solid fats with oils when possible
 - Don't over-restrict
 - Choose baked over fried

Fats in Foods Continued 9

FIGURE 4-5 Cutting Fat Cuts kCalories - and Saturated Fats



Pork chop with fat (290 kcal, 24g fat, 9g saturated fat)



Pork chop with fat trimmed off (174 kcal, 8g fat, 3g saturated fat)

Savings:

116 kcal, 16 g fat, 6 g saturated fat



Potato with 1 tbs butter and 1 tbs sour cream (315 kcal, 14g fat, 9g saturated fat)



Plain potato (188 kcal, <1g fat, 0g saturated fat)

Savings:

127 kcal, 13 g fat, 9 g saturated fat



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



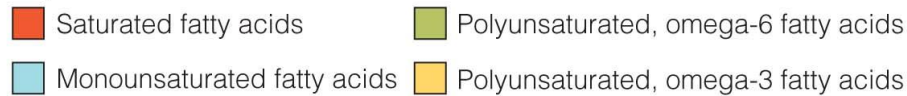
Fat-free milk, 1 c (90 kcal, <1g fat, <1g saturated fat)

Savings:

60 kcal, 7 g fat, 4 g saturated fat

Fats in Foods

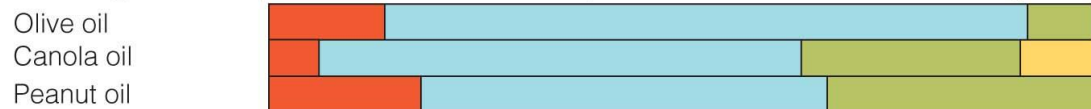
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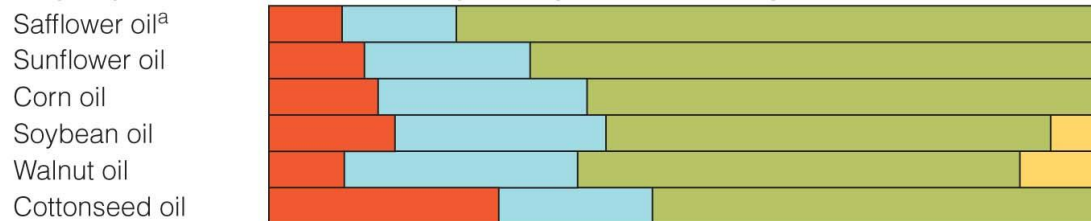
Animal fats and the tropical oils of coconut and palm contain mostly saturated fatty acids.



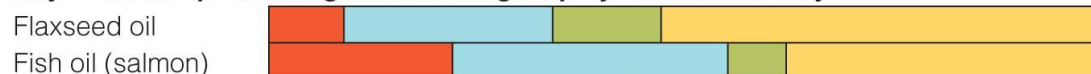
Some vegetable oils, such as olive and canola, are rich in monounsaturated fatty acids.



Many vegetable oils are rich in omega-6 polyunsaturated fatty acids.

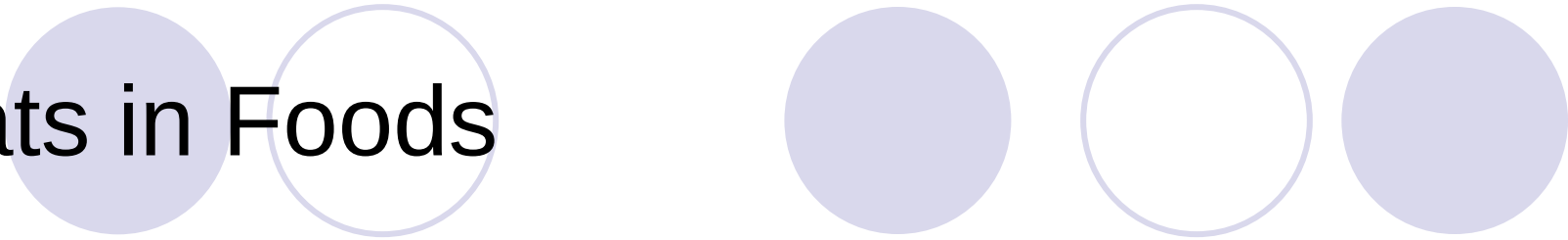


Only a few oils provide significant omega-3 polyunsaturated fatty acids.



^aSalad or cooking type, over 70% linoleic acid.

Fats in Foods

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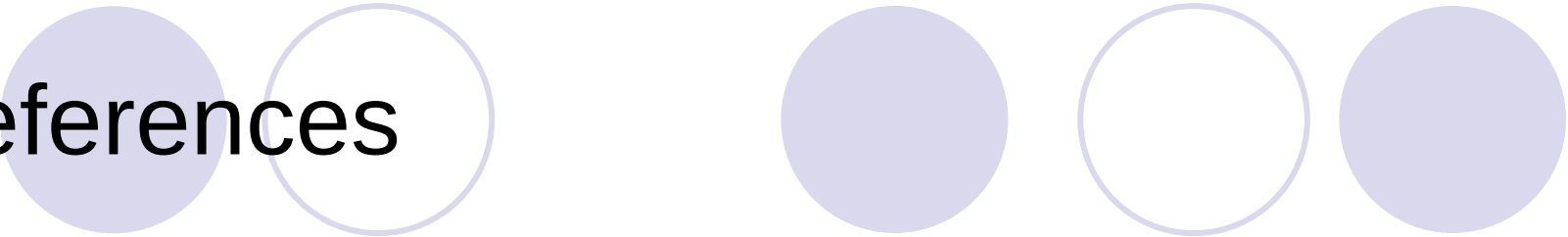
Cutting Solid Fats & Choosing Unsaturated Fats:

- Removing fat also removes energy
- The softer a fat, the more unsaturated it is
- Need to include at least one teaspoon of fat in each meal
- Various fat replacers are available
 - Artificial fat olestra strips body of fat-soluble vitamins
 - Large amounts may cause digestive distress, nutrient losses, and loss of phytochemicals
- Food labels important information source about types and amounts of fat in foods

Fat...An Energy-Yielding Nutrient

- Body uses fat as energy.
- Body is able to store generous amount.

References



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