Chapter 5: Lipids: Fats, Phospholipids, and Sterols

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Student learning outcomes: At the end of this chapter, you should be able to:

- Discuss benefits and risks of dietary fats
- Compare and contrast types of fats
- Select foods containing healthy fats and limit unhealthy fats

THINK about this – then share within a PAIR – then SHARE with the class

- Which foods in your diet provide fat?
- Why do you need fat in your diet?
- What are the benefits and consequences of a low-fat diet?

Sources of dietary fats

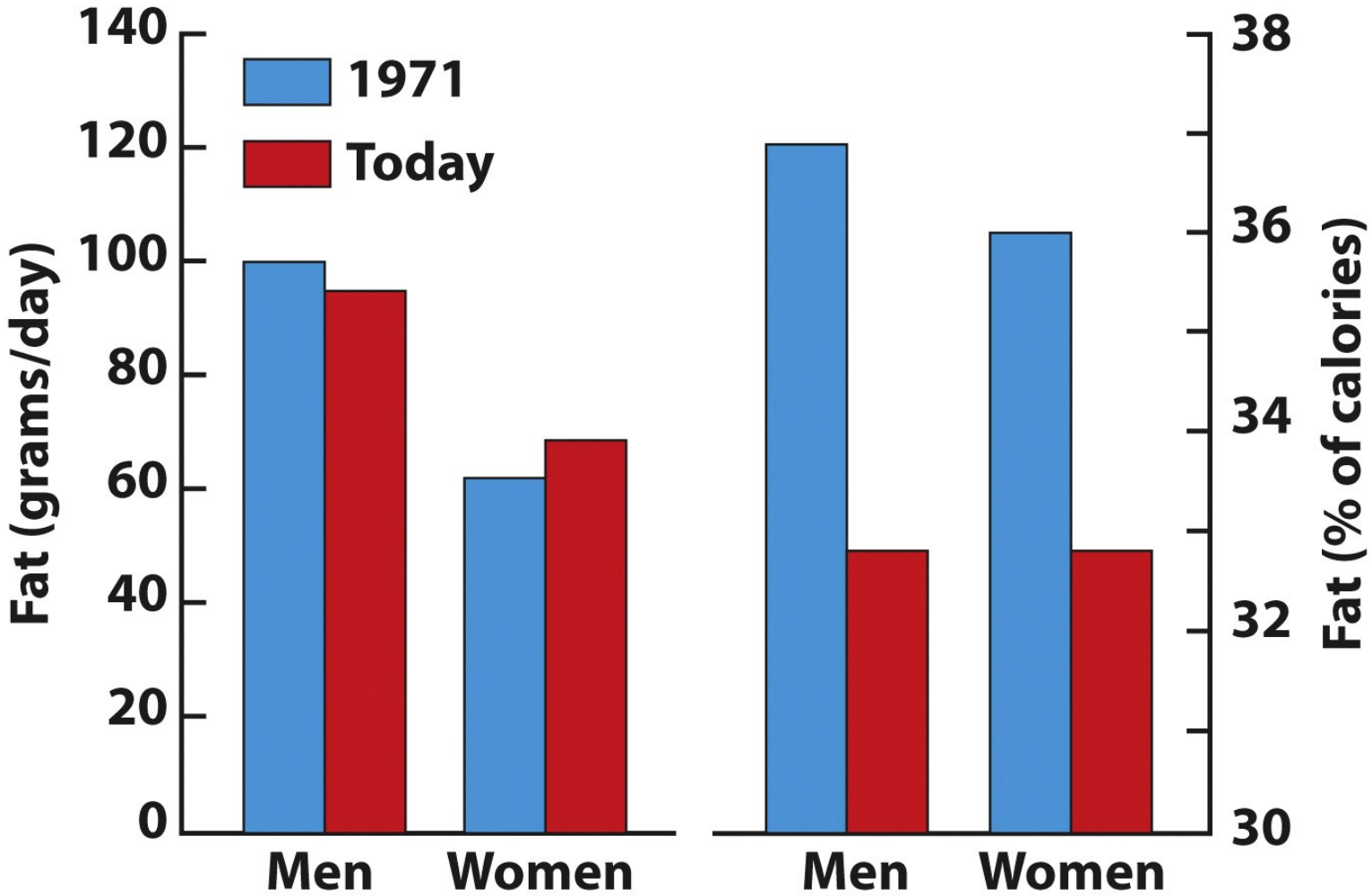
- Animal sources:
  - meat, cheese, dairy
- Plant sources:
  - vegetable oils, nuts, avocados
- “Hidden” dietary fat:
  - French fries, pizza, pasta dishes, baked goods, salad dressings

Benefits of dietary fats

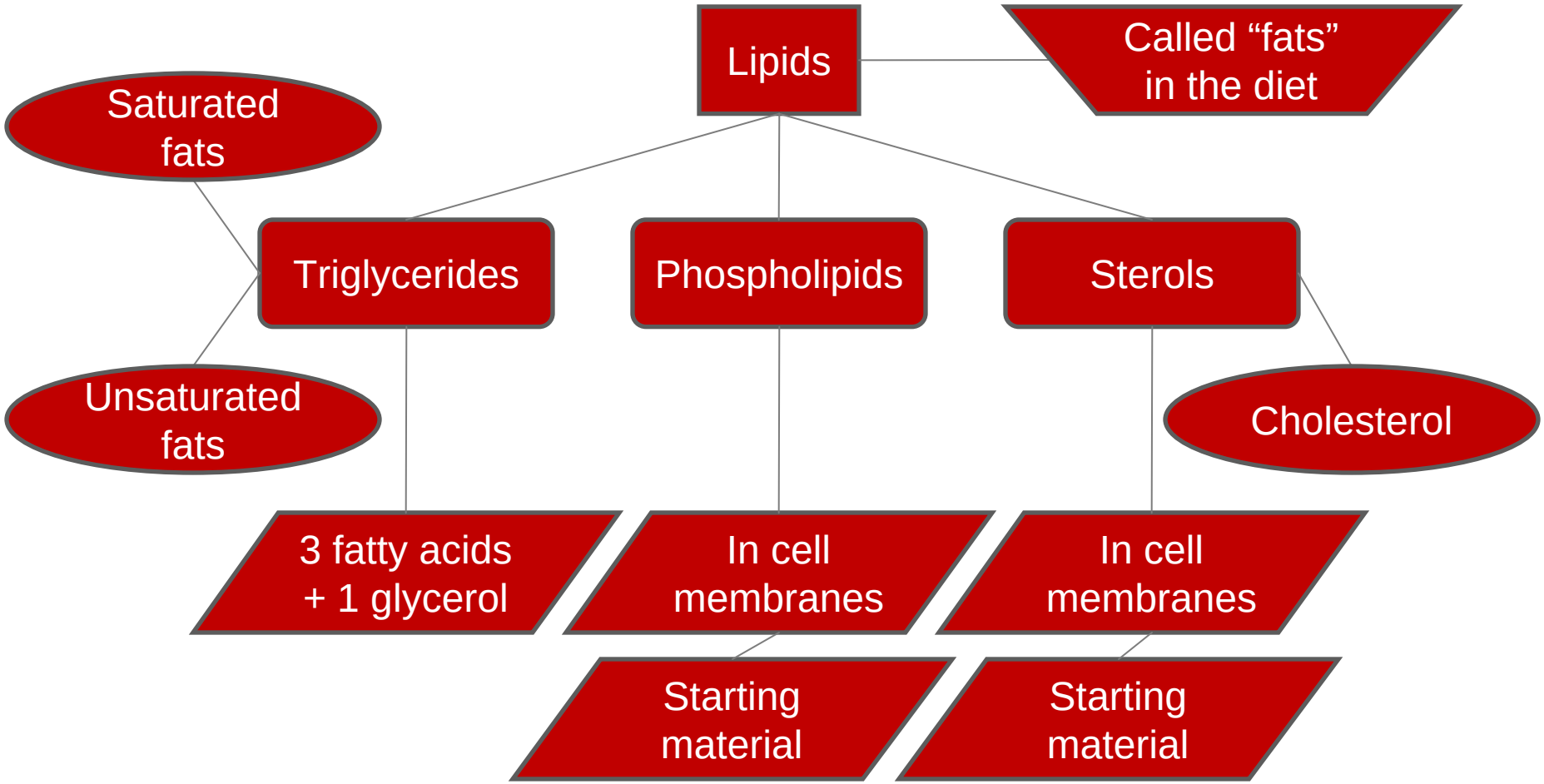
- Provide texture, flavor, aroma to foods

Donald Erickson/iStockphoto

Low-fat diets

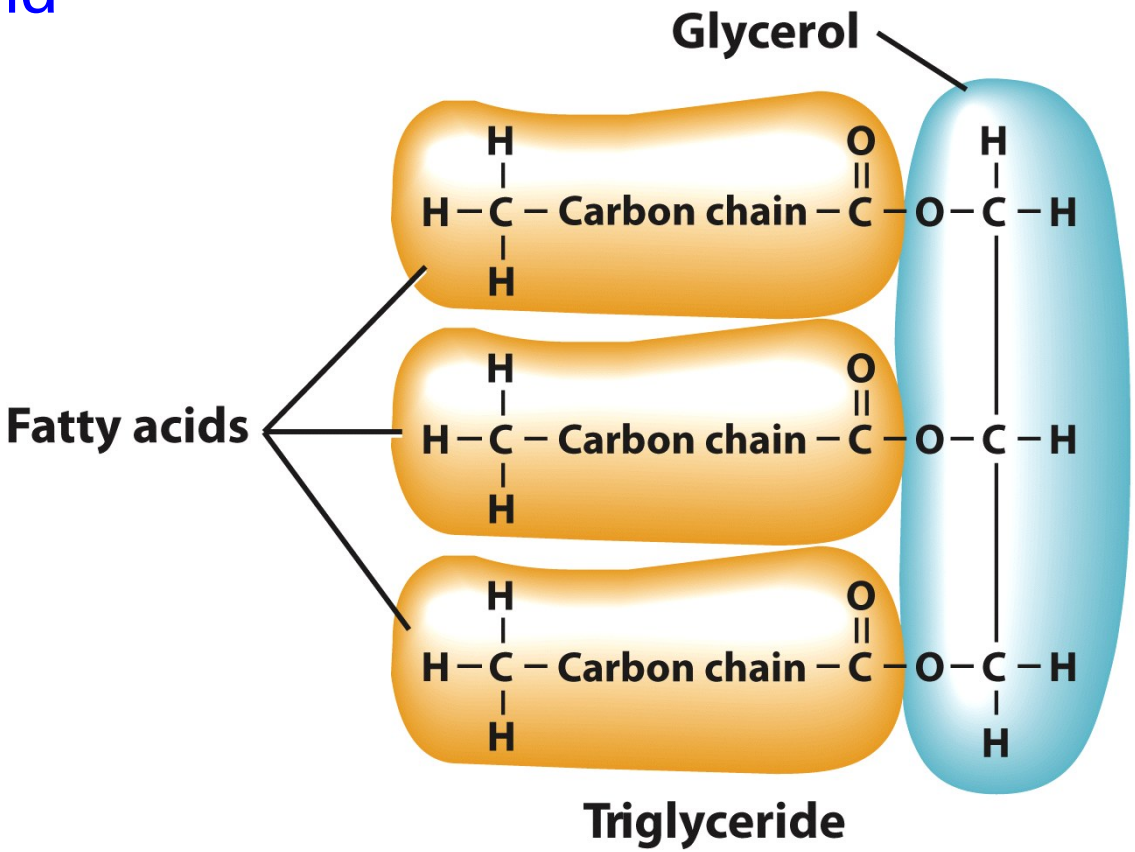


Lipids: a class of large biological molecules



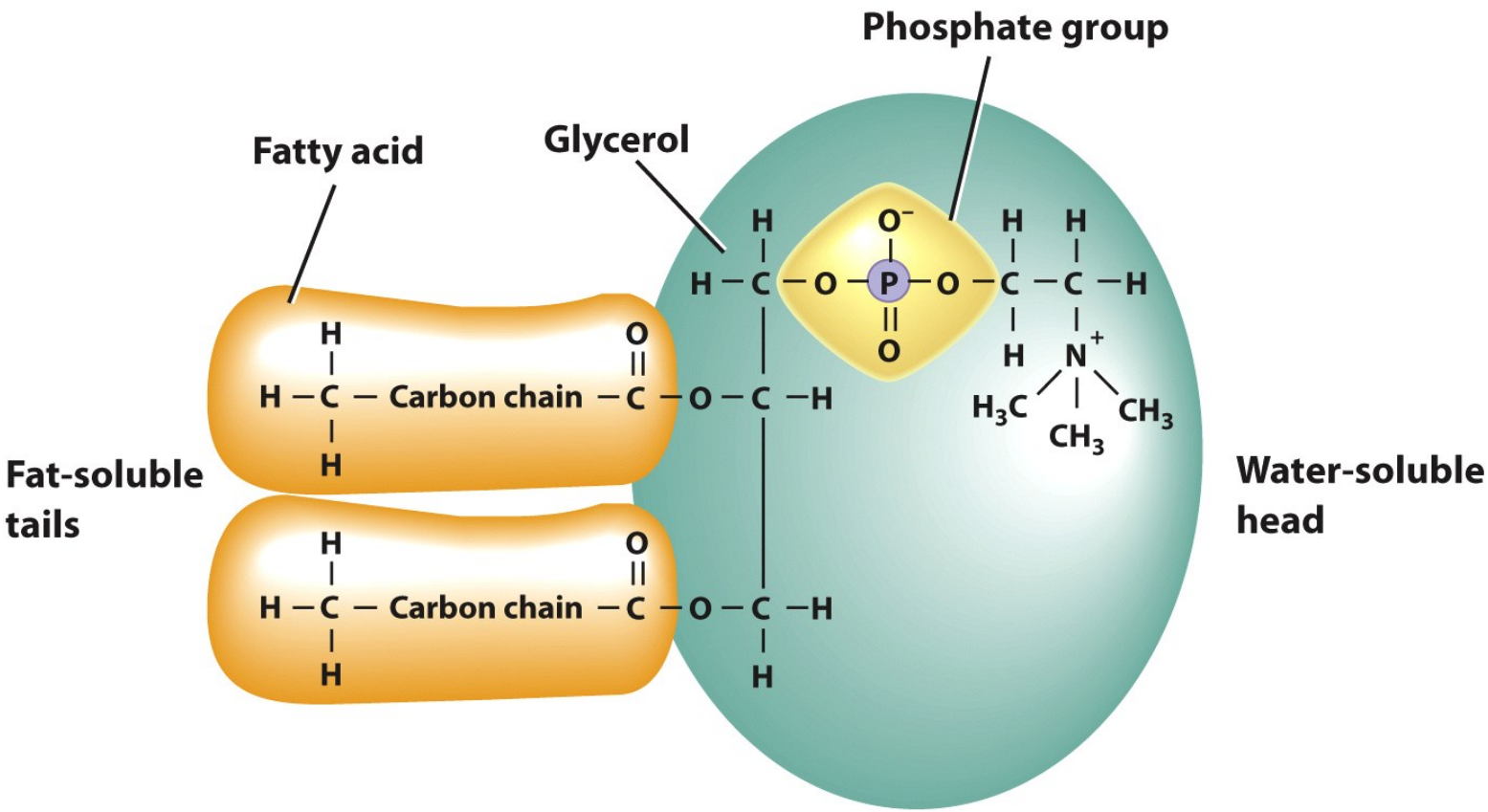
Lipid types / Triglyceride

- Glycerol, fatty acids: chains of carbon atoms, acid at end



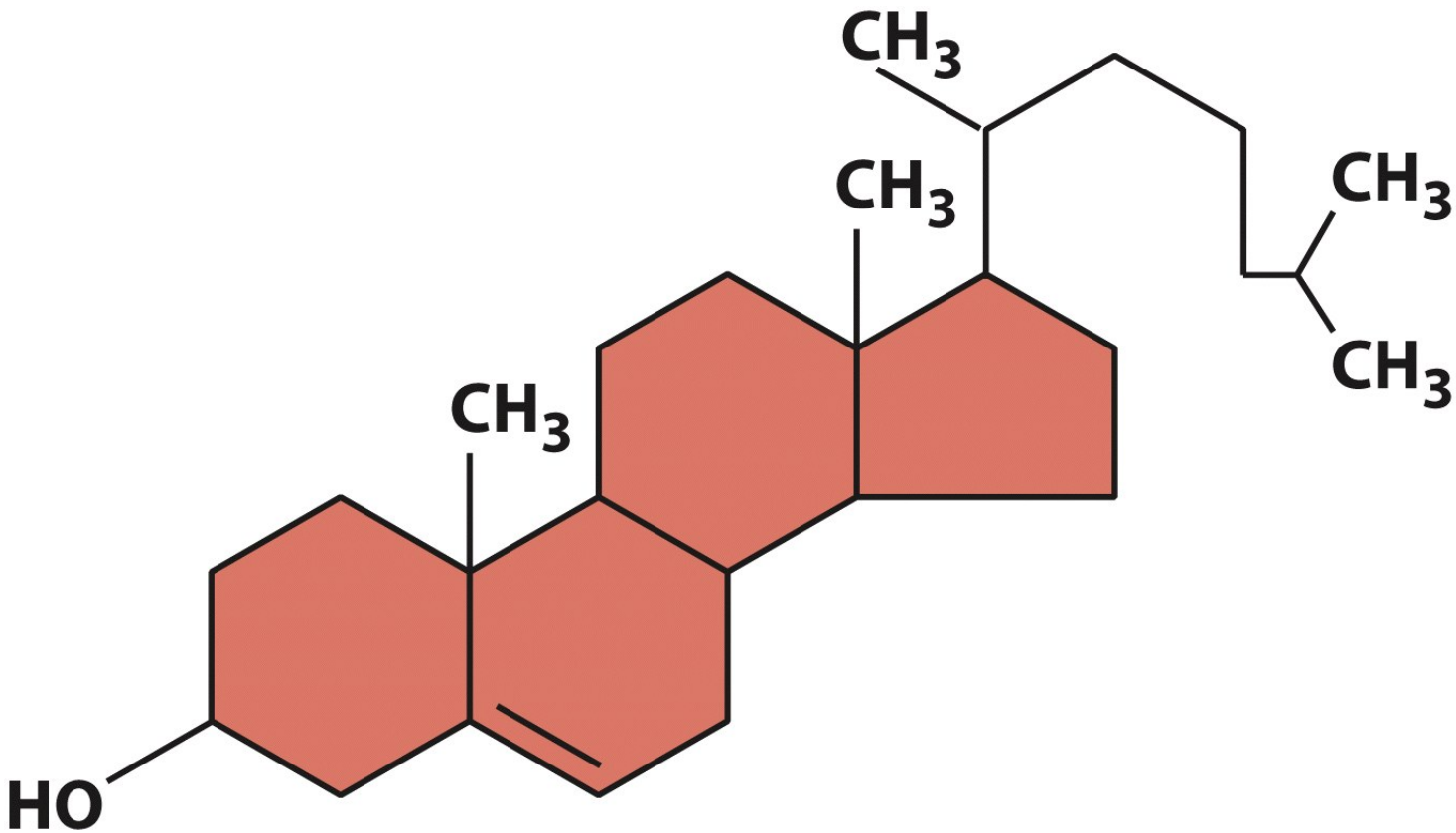
Lipid types / Phospholipid

- Phosphate, chains of carbon atoms



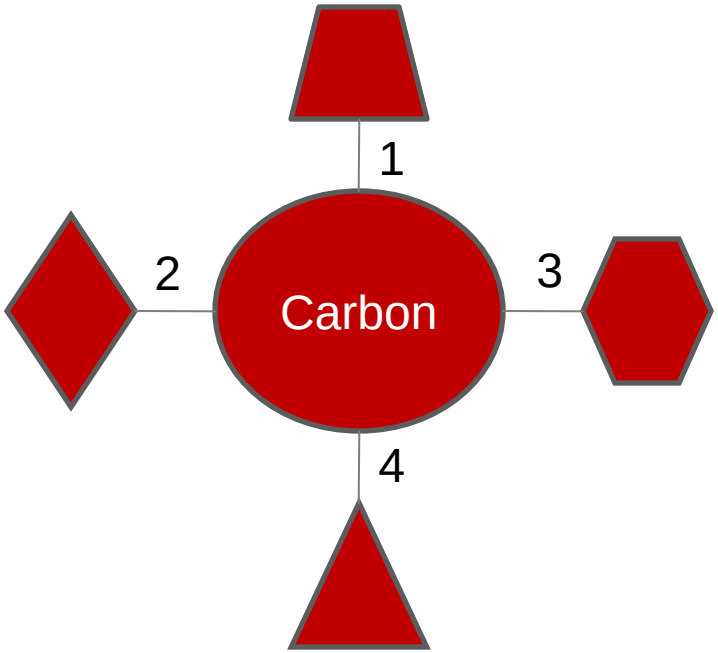
Lipid types / Sterols

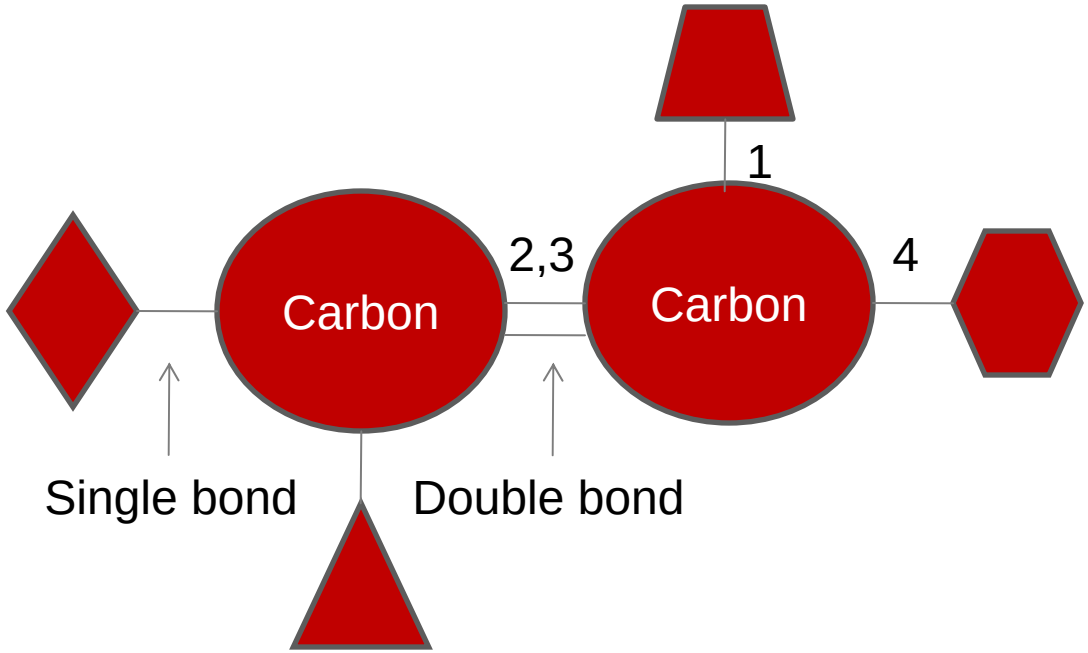
- Multiple chemical rings



Carbon bonding

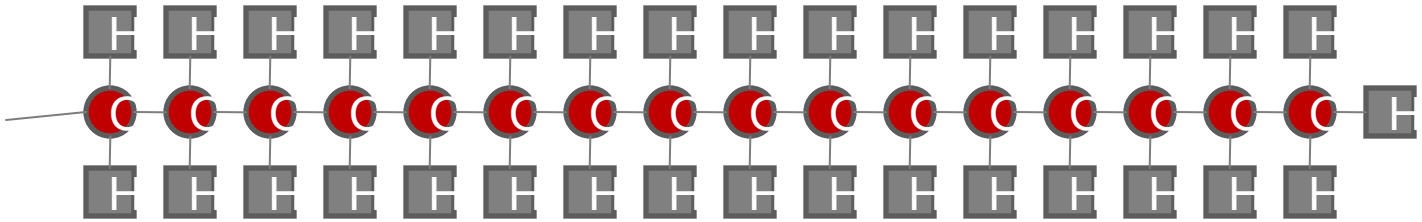
- Carbon can form four bonds



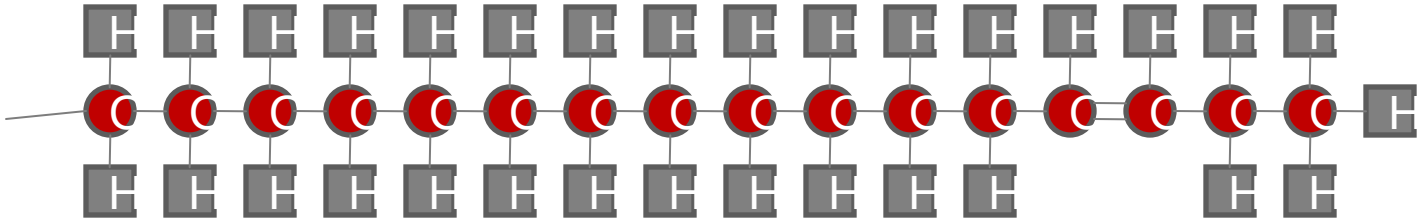


Saturated vs. unsaturated fatty acids

- **Saturated fats:** carbons are saturated by hydrogens



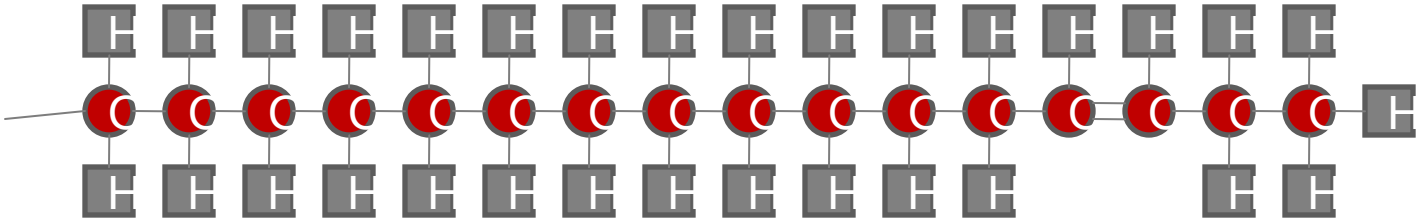
- **Unsaturated fats:** carbons not saturated



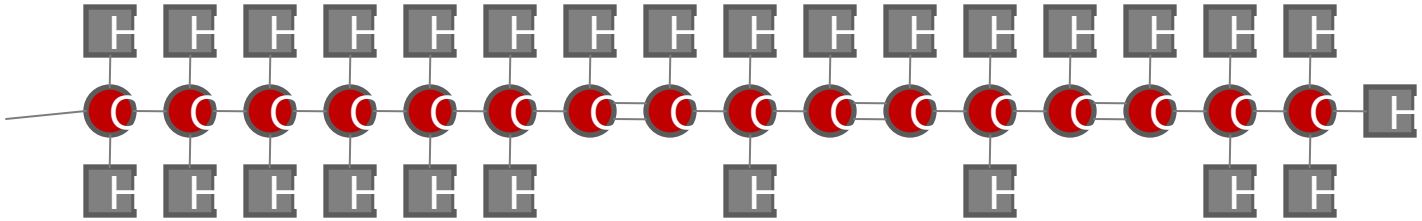
Saturated vs. unsaturated fats in foods

Monounsaturated vs. polyunsaturated fats

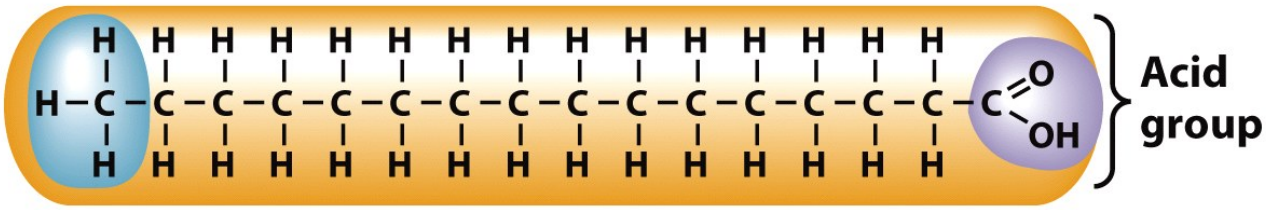
- Monounsaturated fats: one double bond

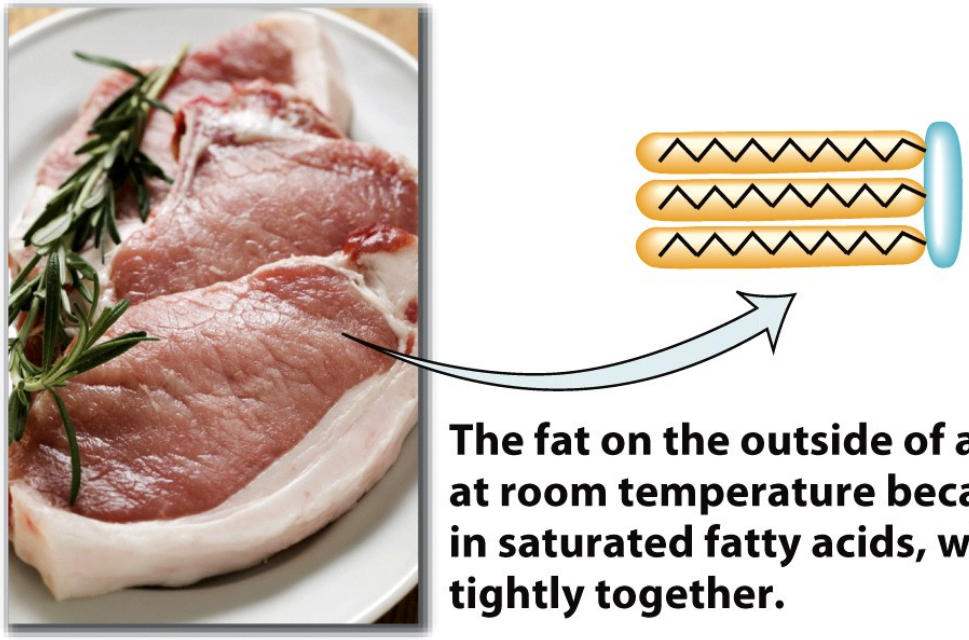


- Polyunsaturated fats: more than one double bond



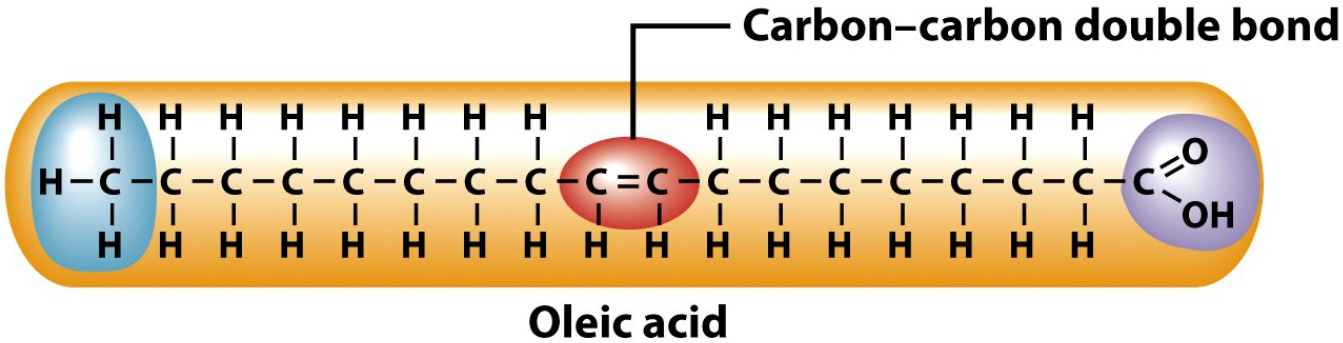
Types of fatty acids

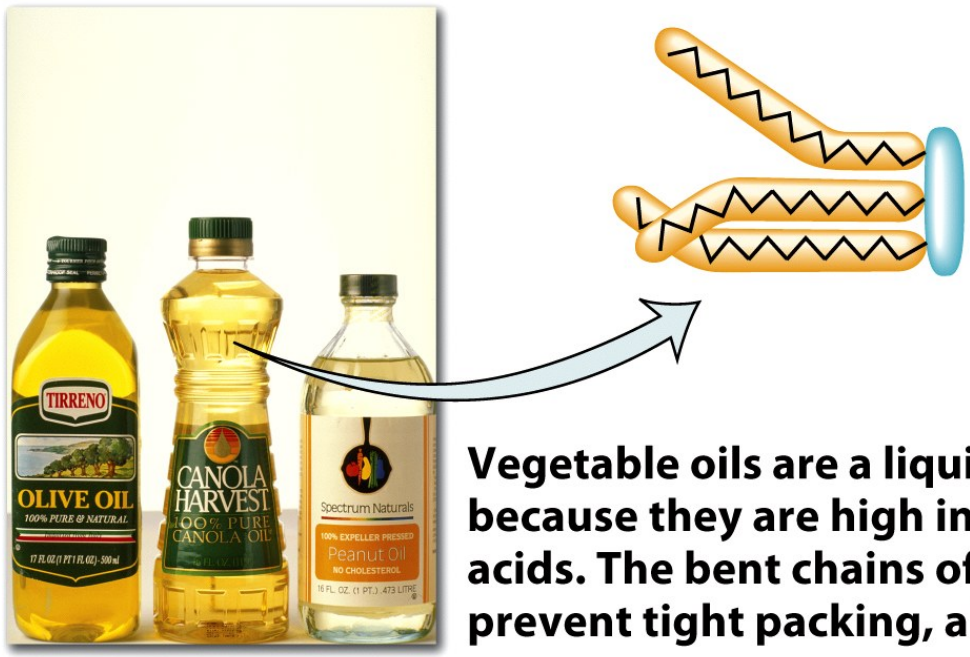




The fat on the outside of a steak is solid at room temperature because it is high in saturated fatty acids, which pack tightly together.

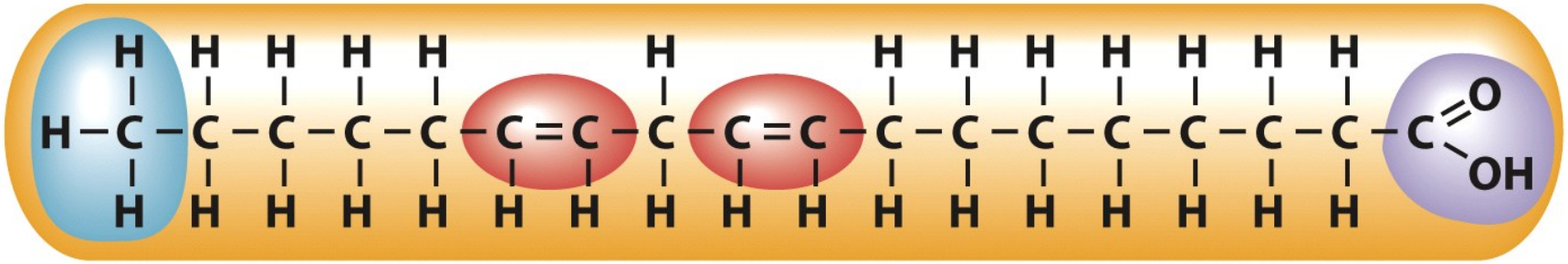
Types of fatty acids



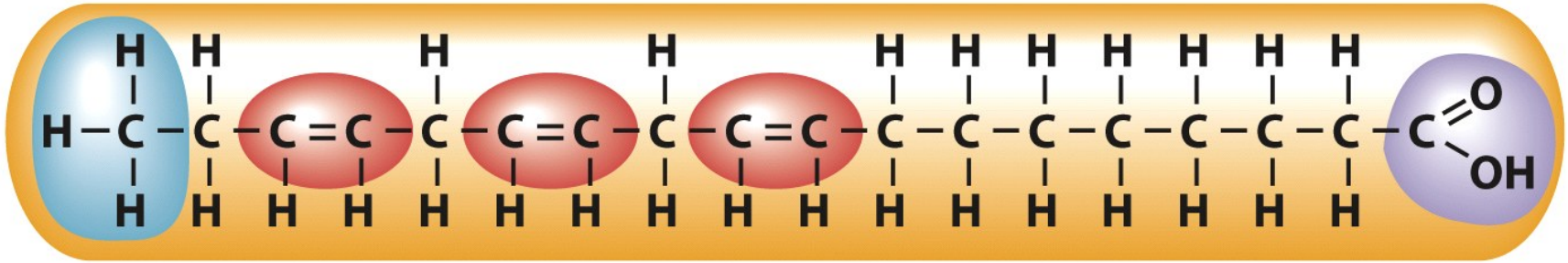


Vegetable oils are a liquid at room temperature because they are high in unsaturated fatty acids. The bent chains of these fatty acids prevent tight packing, allowing the oil to flow.

Types of Fatty Acids



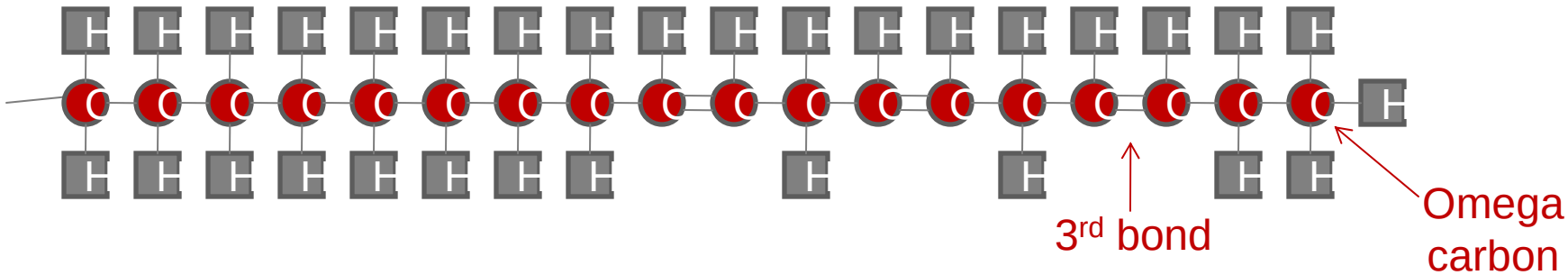
Linoleic acid



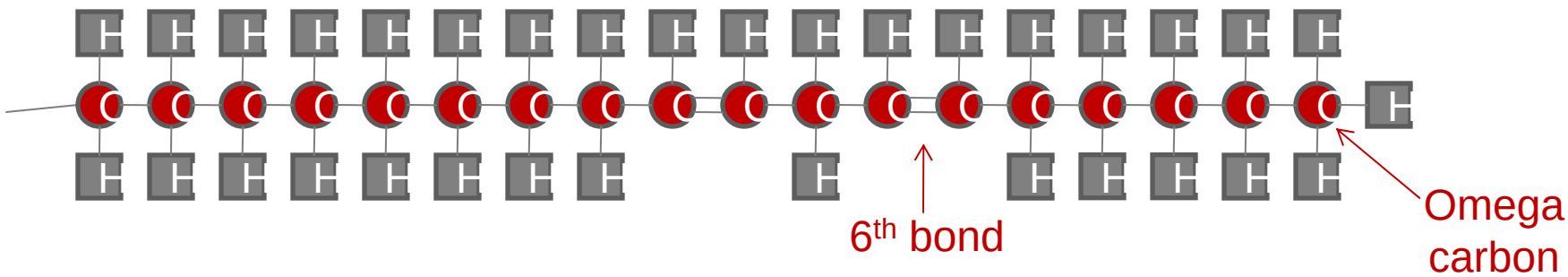
Alpha-linolenic acid

Omega-3 vs. Omega-6 polyunsaturated fats

- Omega-3: first double bond at 3rd bond from omega end



- Omega-6: first double bond at 6th bond from omega end

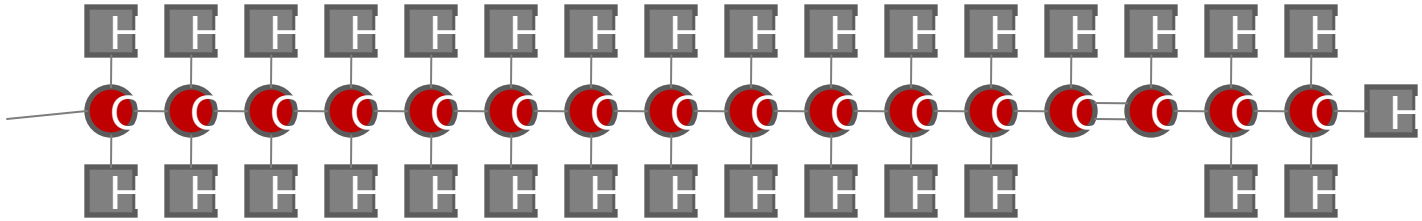


Essential vs. non-essential fatty acids

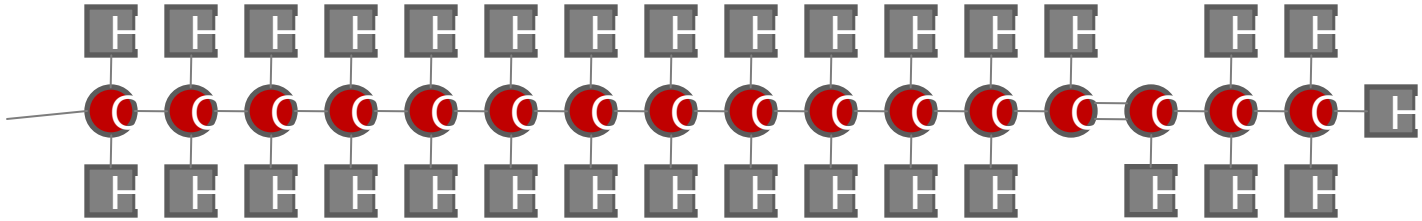
- **Essential fatty acids cannot be made in the body, so they are essential in the diet /// Example: omega-3 fatty acids (e.g. alpha-omega-6-fatty acids) and omega-6 (e.g. linoleic acid)**
  - **Sources:**
  - **omega-3 = flaxseed, walnuts, soy (decreases inflammation-blood clotting-blood pressure)**
  - **omega-6 = vegetable oils and meats (increases inflammation-blood clotting-blood pressure)**
- **Non-essential fatty acids can be made by the body, so they are not essential in the diet**

Cis vs. *trans*-fats

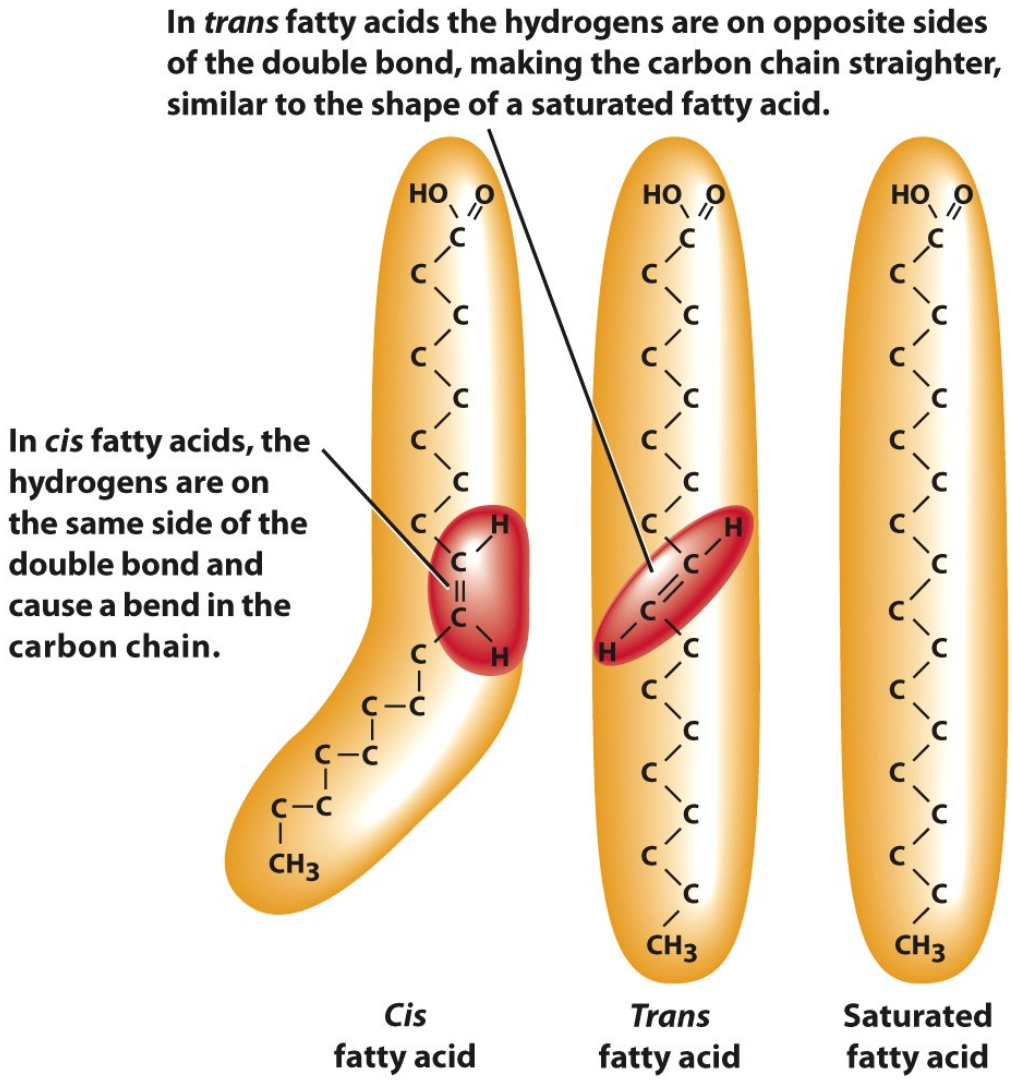
- *Cis* fat: hydrogens on same side (like sisters)



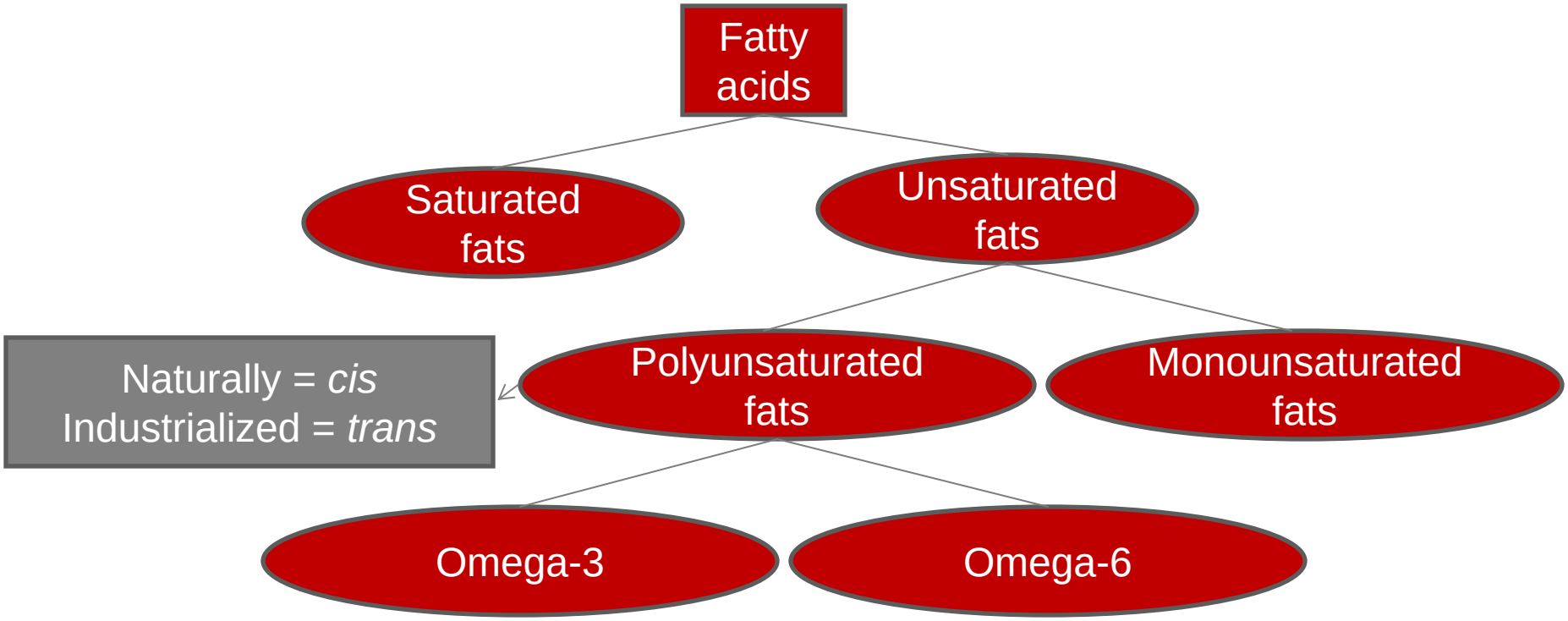
- *Trans* fat: hydrogens are across (like a transcontinental flight goes across the US)



Cis vs. *trans*-fats



Types of fatty acids



Trans-fat (*trans*-fatty acids)

- Found naturally in small amounts (e.g. dairy products)
- Large amounts created when unsaturated fatty acids are partially converted to saturated fatty acids by the industrialized process of hydrogenation
  - Decreases the reactivity of lipids / used to decrease rancidity and increase shelf life
  - *Most dangerous dietary fat*
  - Look for "hydrogenated oils" in ingredients list // avoid this type of fat!!!

Trans-fat vs. palm oil

- *Trans*-fat food labeling led food producers to replace hydrogenated oil with palm oil
- Palm oil is a tropical oil high in saturated fat
- Increased palm oil production led to rainforest destruction

Trans-fat (*trans*-fatty acids)

Chocolate Chip Cookies

Nutrition Facts
Serving Size 3 Cookies (33g)
Servings Per Container About 13

Amount Per Serving	
Calories 160	Calories from Fat 70
	% Daily Value*
Total Fat 8g	12%
Saturated Fat 3g	15%
Trans Fat 0g	
Polyunsat Fat 2.5g	
Monounsat Fat 2g	
Cholesterol 0mg	0%
Sodium 110mg	5%
Potassium 45mg	1%
Total Carbohydrate 22g	7%
Dietary Fiber Less than 1gram	3%
Sugars 11g	
Protein 2g	

Vitamin A 0%	•	Vitamin C 0%	
Calcium 0%	•	Iron 4%	

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Potassium	Less than	3,500mg	3,500mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

INGREDIENTS: ENRICHED FLOUR (WHEAT FLOUR, NIACIN, REDUCED IRON, THIAMINE MONONITRATE (VITAMIN B1), FOLIC ACID, SEMISWEET CHOCOLATE CHIPS (SUGAR, CHOCOLATE, COCOA BUTTER, DEXTROSE, SOY LECITHIN AN EMULSIFIER), SUGAR, SOY BEAN OIL AND/OR PARTIALLY HYDROGENATED COTTONSEED OIL, HIGH FRUCTOSE CORN SYRUP, LEAVENING (BAKING SODA AND/OR AMMONIUM PHOSPHATE), SALT, WHEY (FROM MILK), NATURAL AND ARTIFICIAL FLAVOR, CARAMEL COLOR.
CONTAINS: WHEAT, SOY, MILK

The Nutrition Facts panel lists Calories from fat; grams of total fat, saturated fat, and *trans* fat; and milligrams of cholesterol in a serving. The amount of monounsaturated and polyunsaturated fat is voluntarily included on the labels of some products.

A % Daily Value is listed for total fat, saturated fat, and cholesterol. This allows consumers to tell how a food fits the recommendations. Generally, ″ 5% of the Daily Value is low, and ≥20% is high. There are no Daily Values for *trans*, polyunsaturated, and monounsaturated fats.

If the product has less than 0.5 gram of *trans* fat per serving, the nutrition facts panel will list the amount of *trans* fat as 0, even if partially hydrogenated oil is an ingredient.

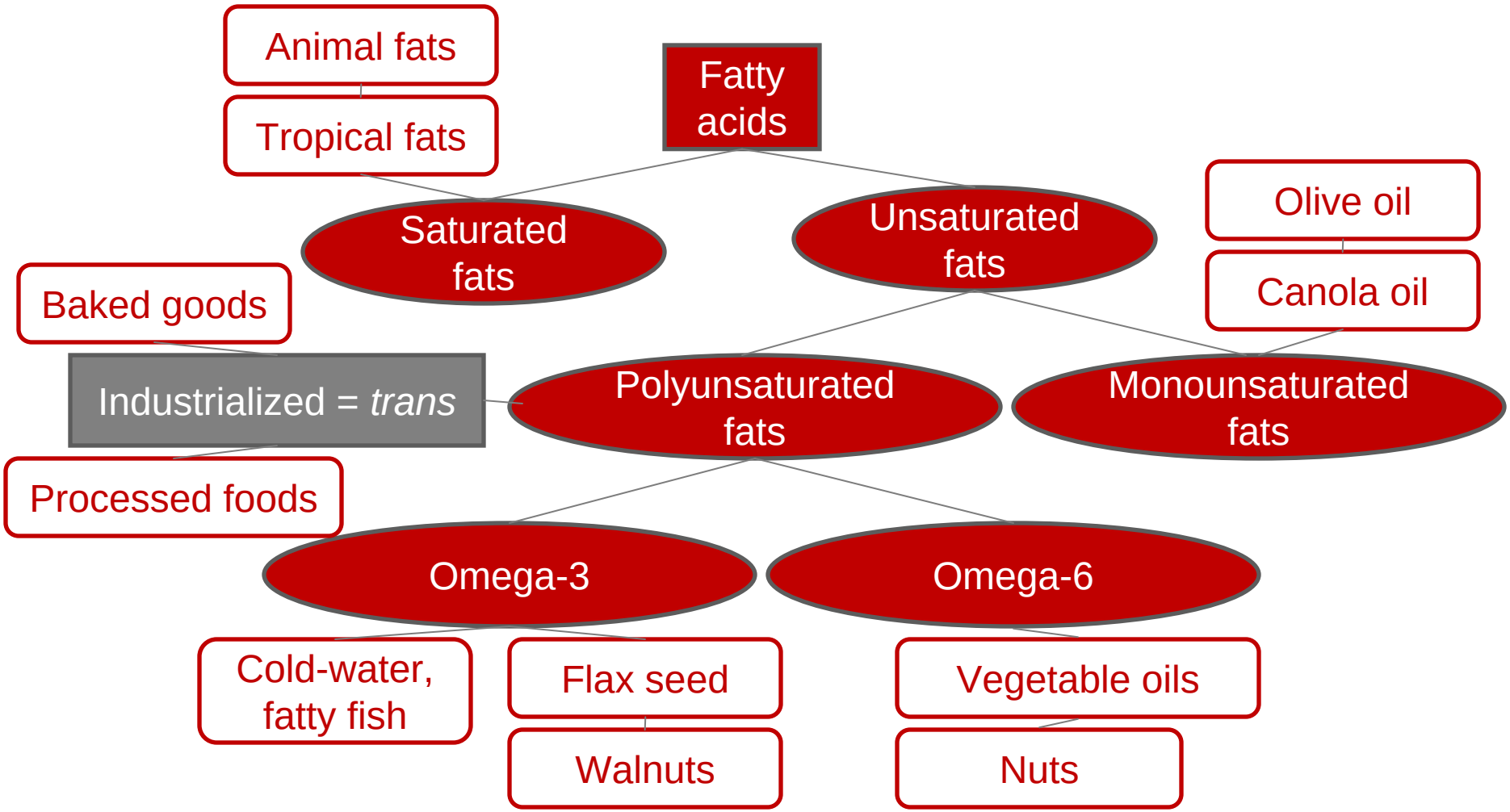
The Daily Values recommend consuming less than 30% of calories as fat, no more than 300 mg of cholesterol per day, and no more than 10% of calories as saturated fat. It is recommended that *trans* fat intake be limited to the amounts present naturally in meats and dairy products (″ 0.5% of calories).

The sources of fat in a product are listed in the ingredient list with the other ingredients, in order of prominence by weight.

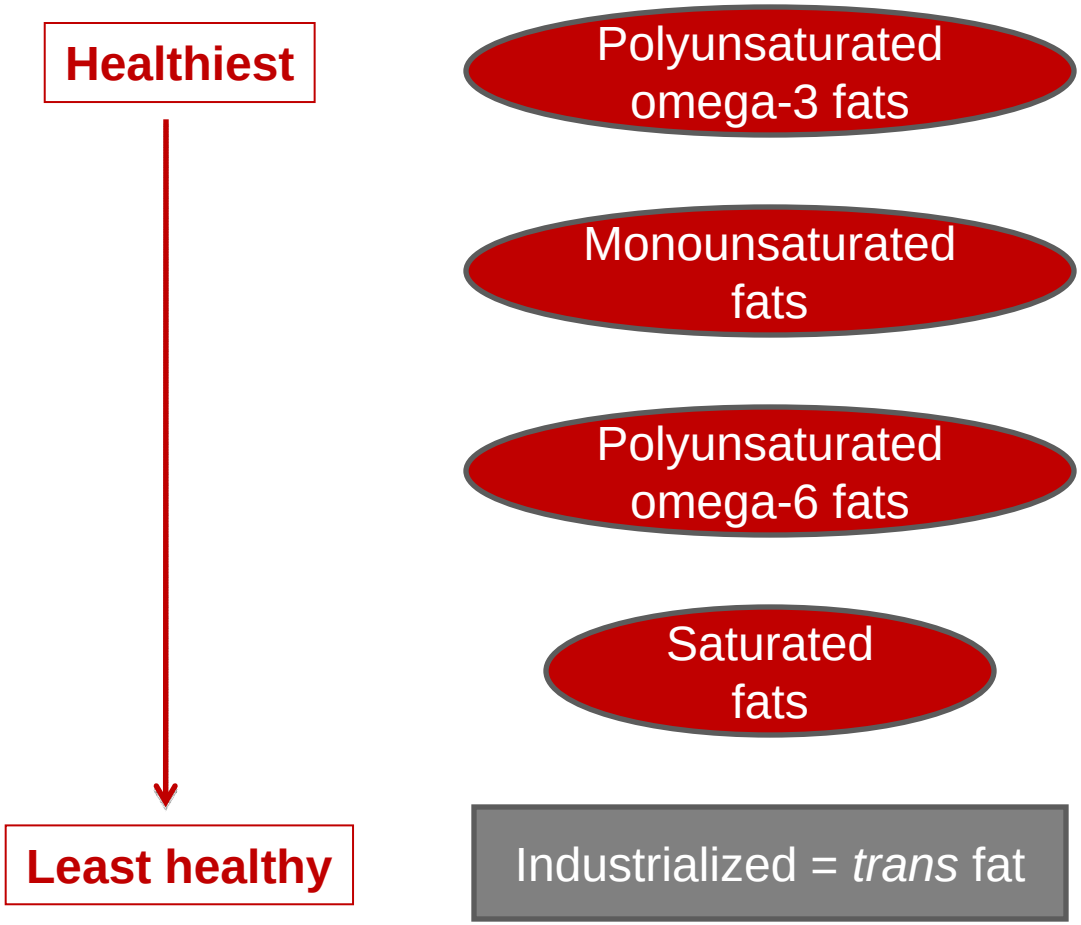
Calculate the *trans*-fat

- Food industry able to “mislead the consumer // in trans-fat labeling zero actually means 0.4 grams
- A bag of chips has 8 servings and <u>has a *trans*-fat free label</u>
- Each serving actually has 0.4 g of *trans* fat (label lists as 0 g of fat)
- If you eat ½ of the bag of chips, how many grams of *trans*-fat have you consumed?

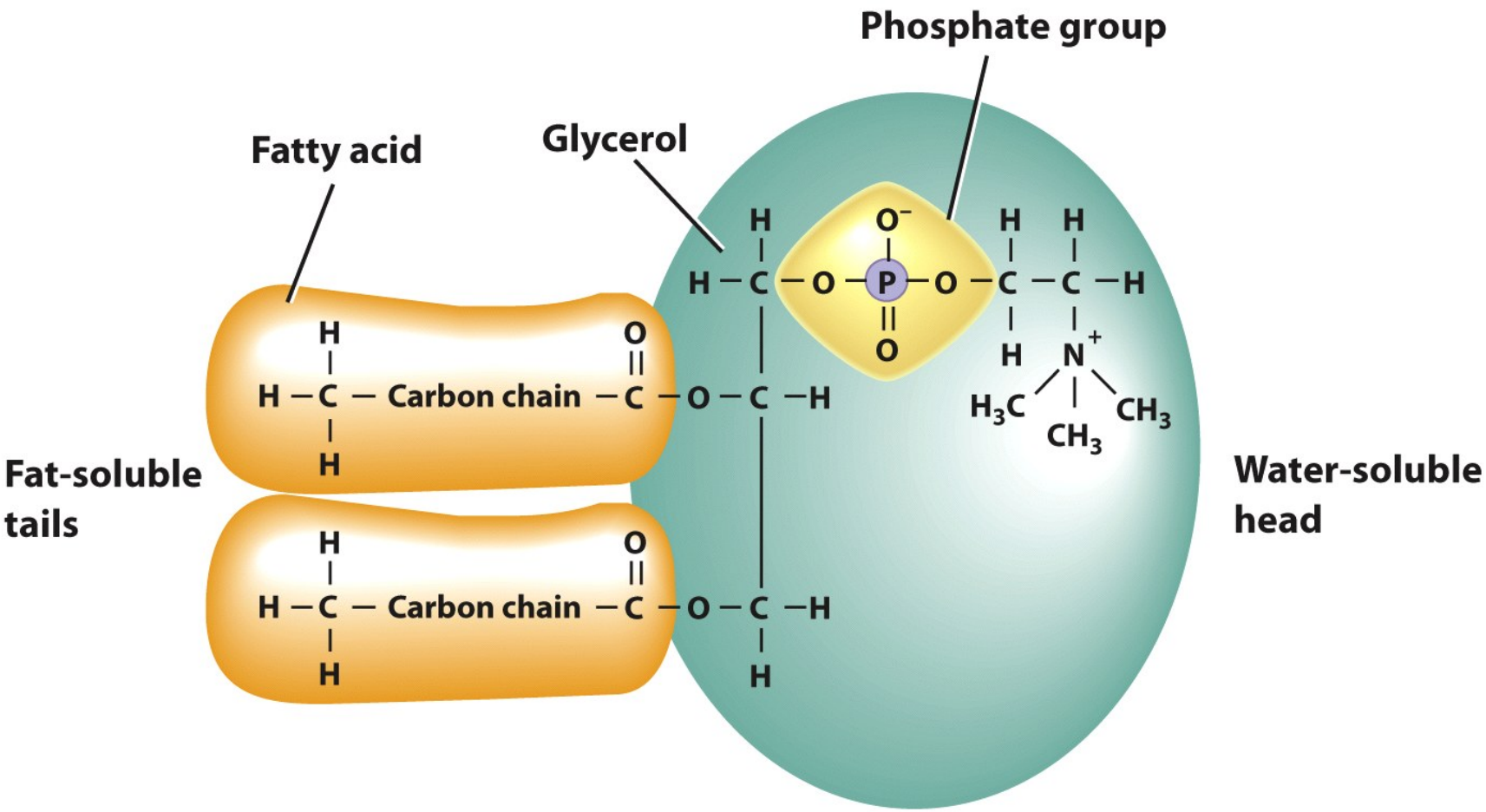
Types of fatty acids



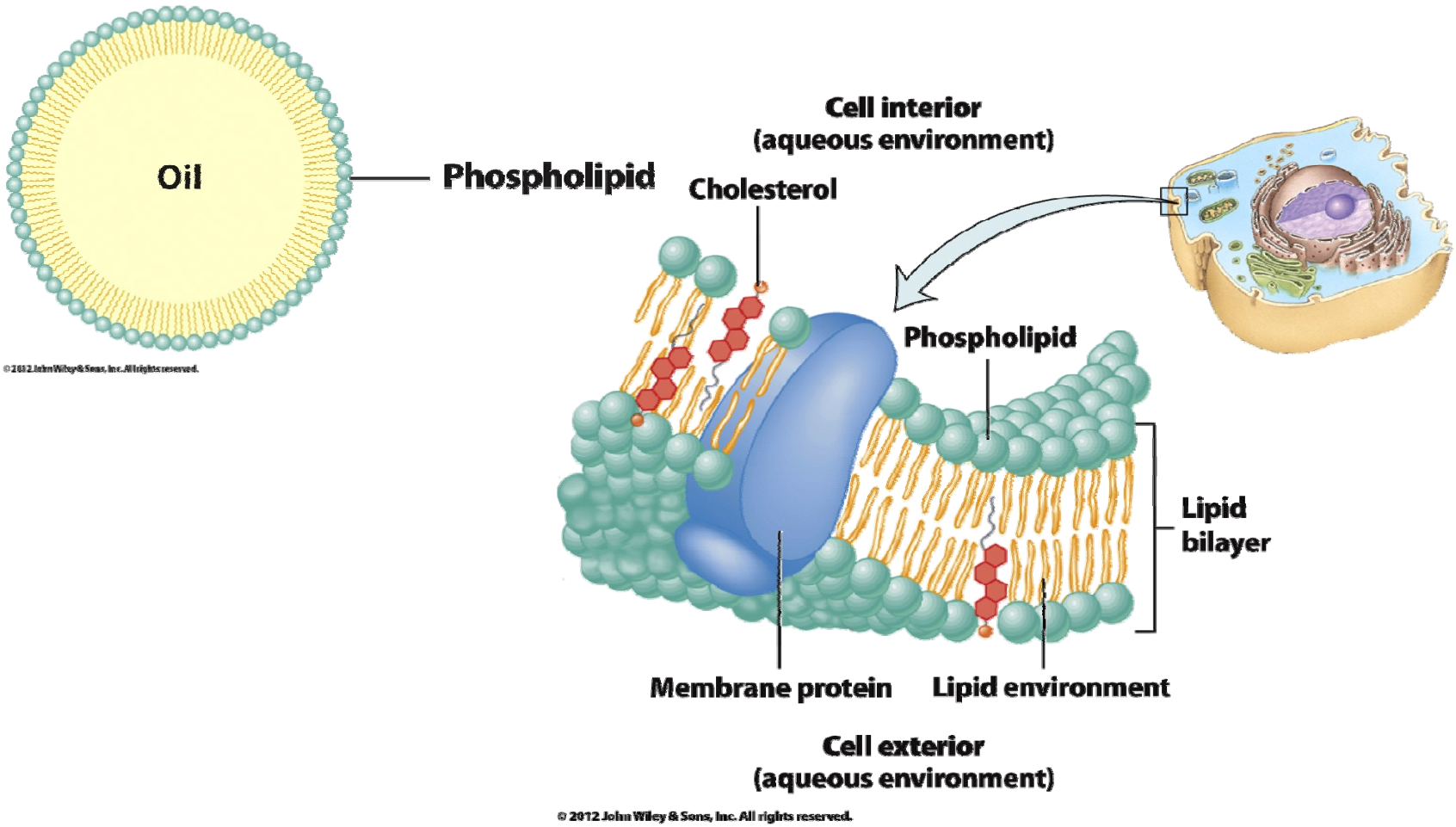
Less healthy to healthier dietary fats



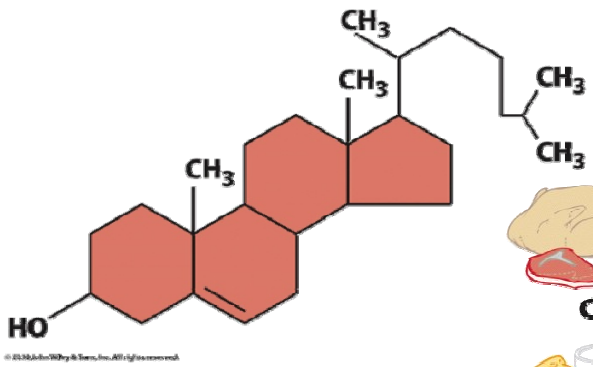
Phospholipids

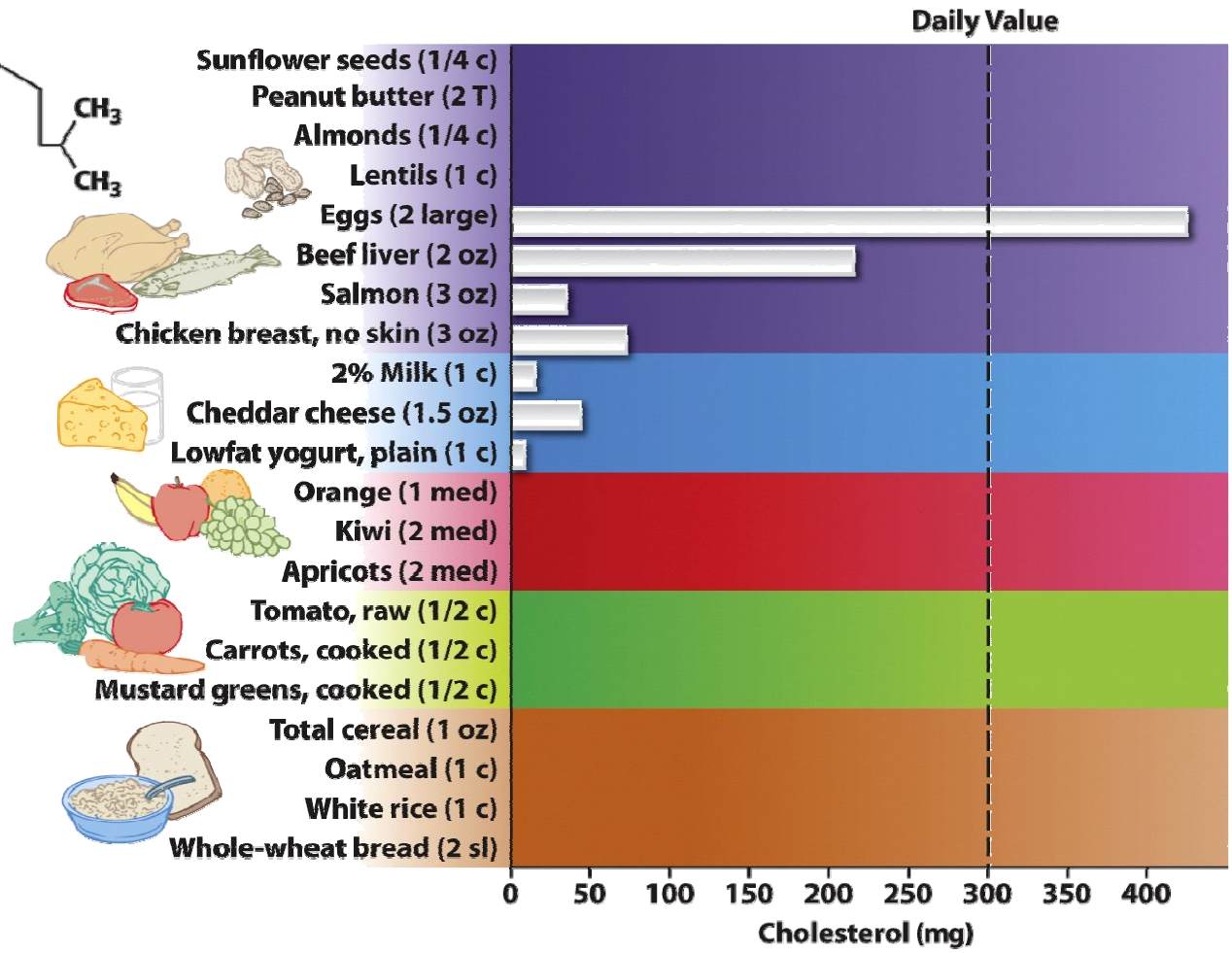


Phospholipids: in cell membranes and used to make other molecules



Cholesterol: in cell membranes and used to make other molecules





Phospholipids

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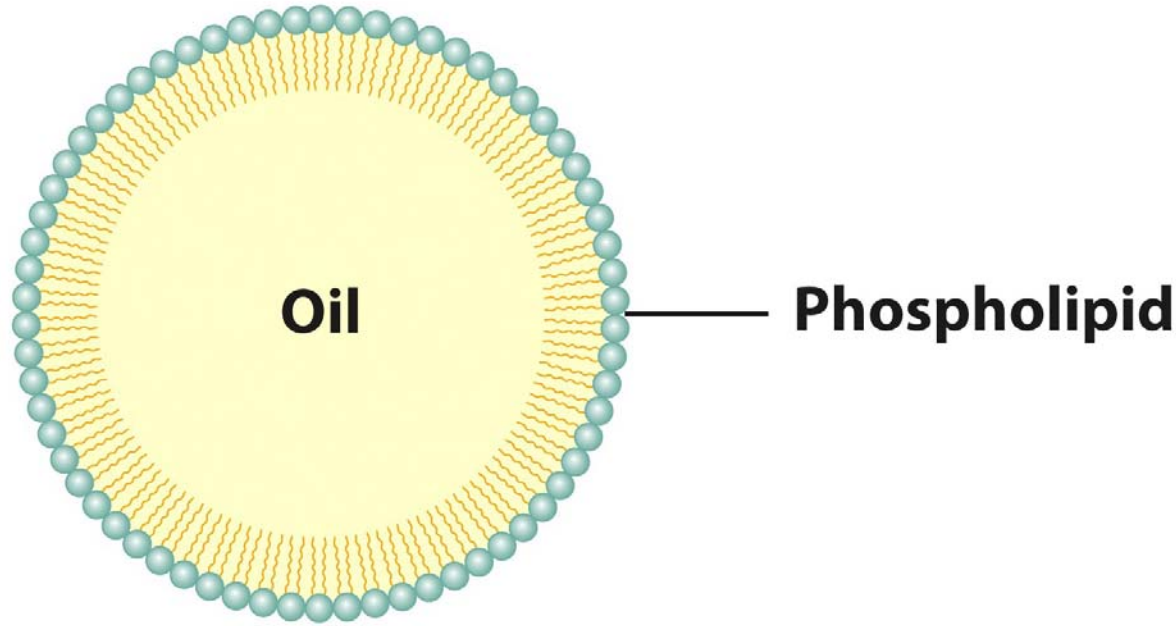
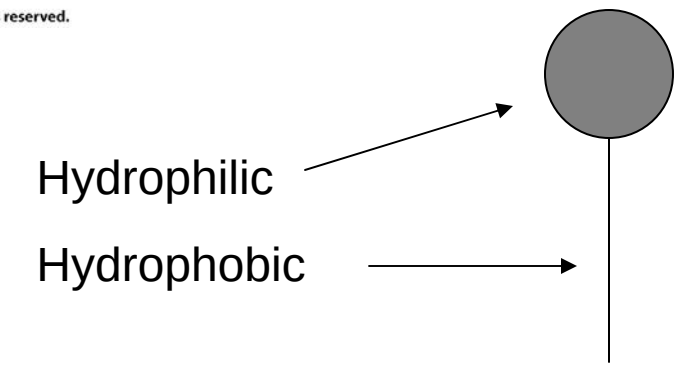
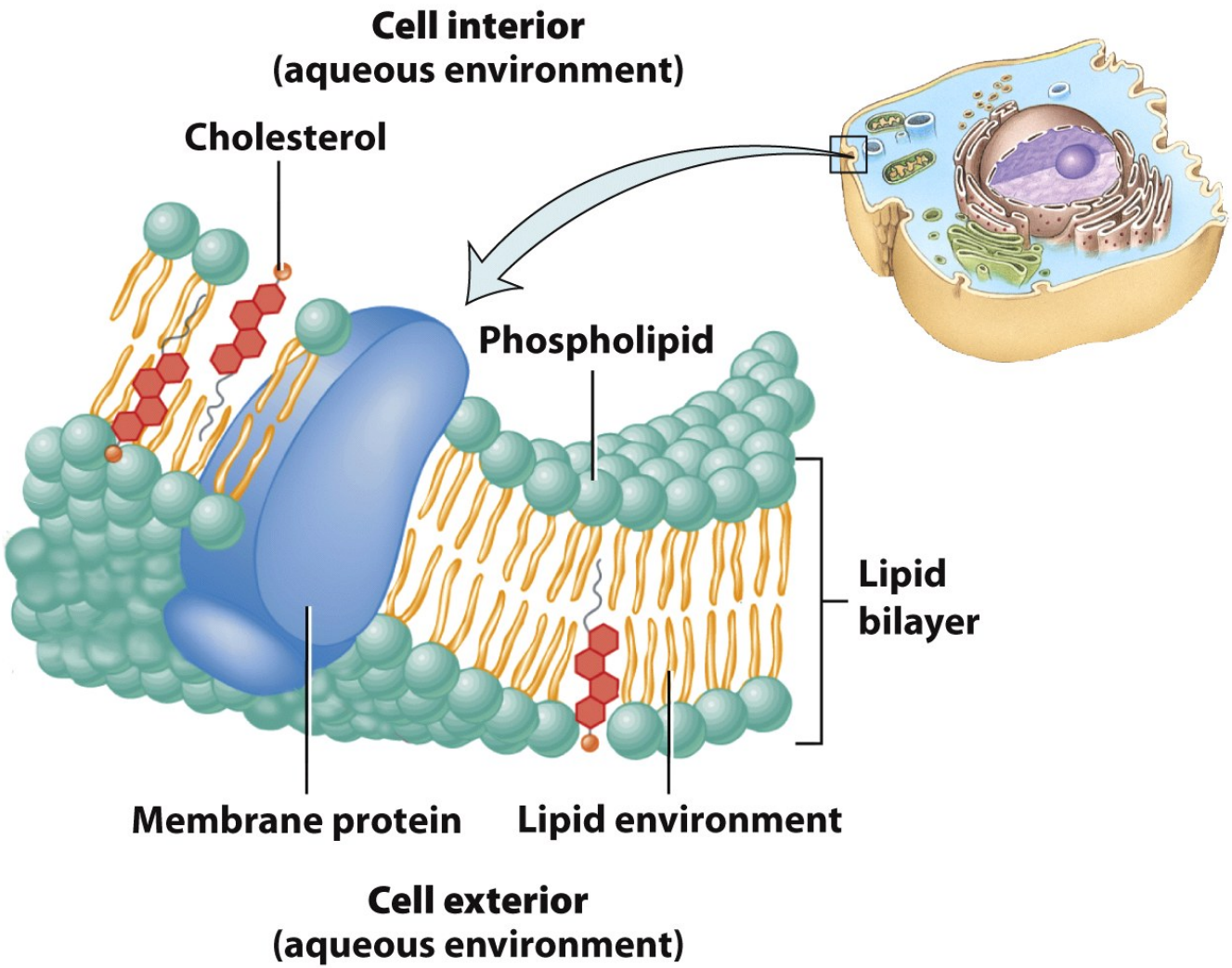




Phospholipids



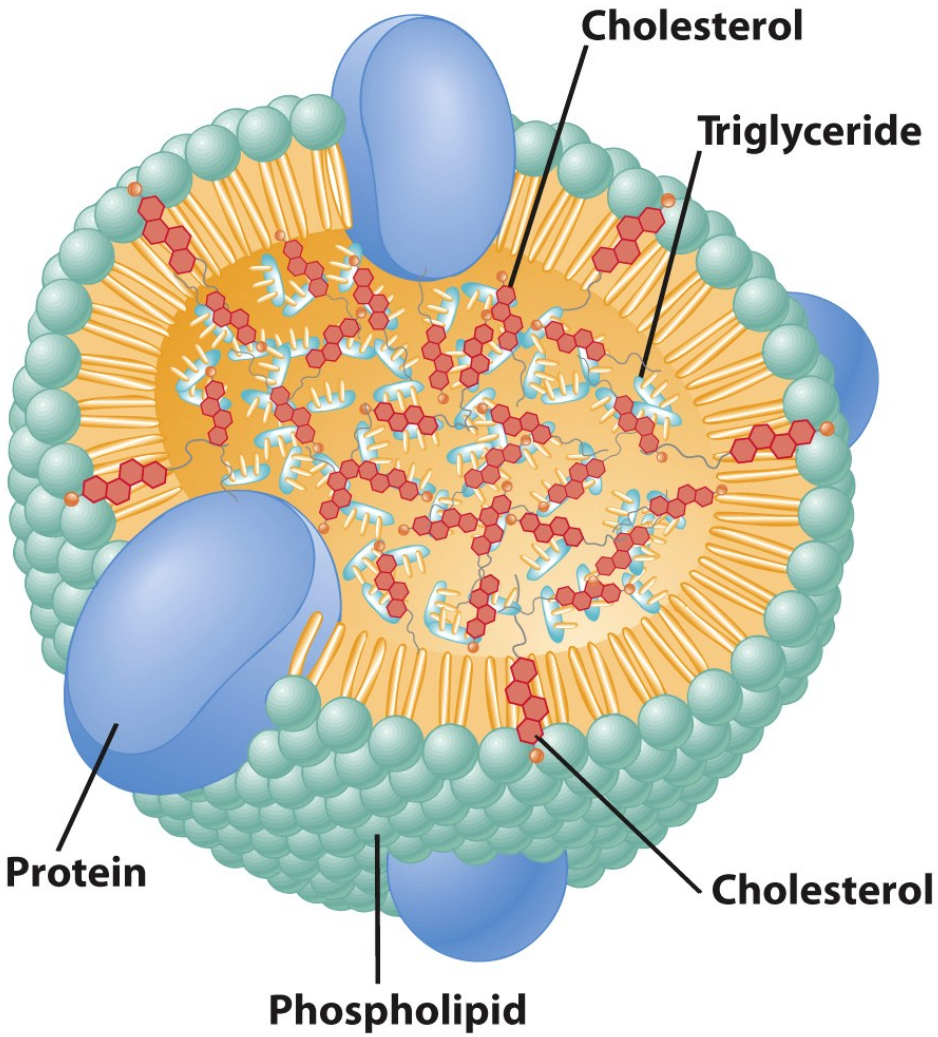
Cholesterol: an animal sterol

- Non-essential nutrient /// made by the liver
- In cell membranes of animal cells
  - Dietary sources: animal products
  - Plant sterols can reduce human cholesterol
- Used to make vitamin D and steroid hormones (for example: estrogen, testosterone, cortisol)

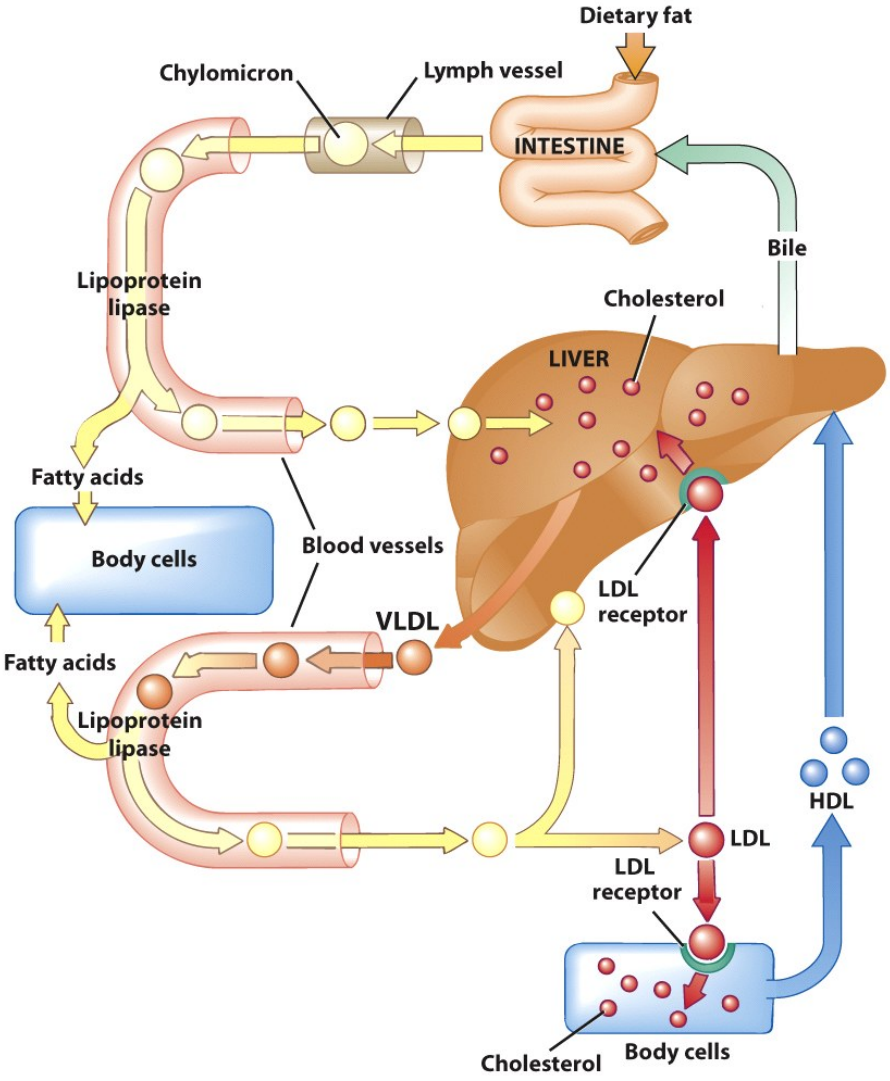
Cholesterol transport in blood

- Lipids are hydrophobic = water fearing // (Oil and water don't mix)
- Blood is mostly water
- In order to transport lipids you need to surrounded lipids by hydrophilic transporters // (= water loving) molecules for transport in blood

Lipoproteins (examples: LDL & HDL)



Lipoproteins in blood



Chylomicrons

- Chylomicrons transport triglycerides, cholesterol, and fat-soluble vitamins from the small intestines to the liver

- Triglycerides in chylomicrons are broken down into glycerol and fatty acids by lipoprotein lipase (in blood vessels) to cross membranes then are reassembled into triglycerides in somatic cells and adipocytes

  - Note: empty chylomicron remnants are returned to the liver for recycling

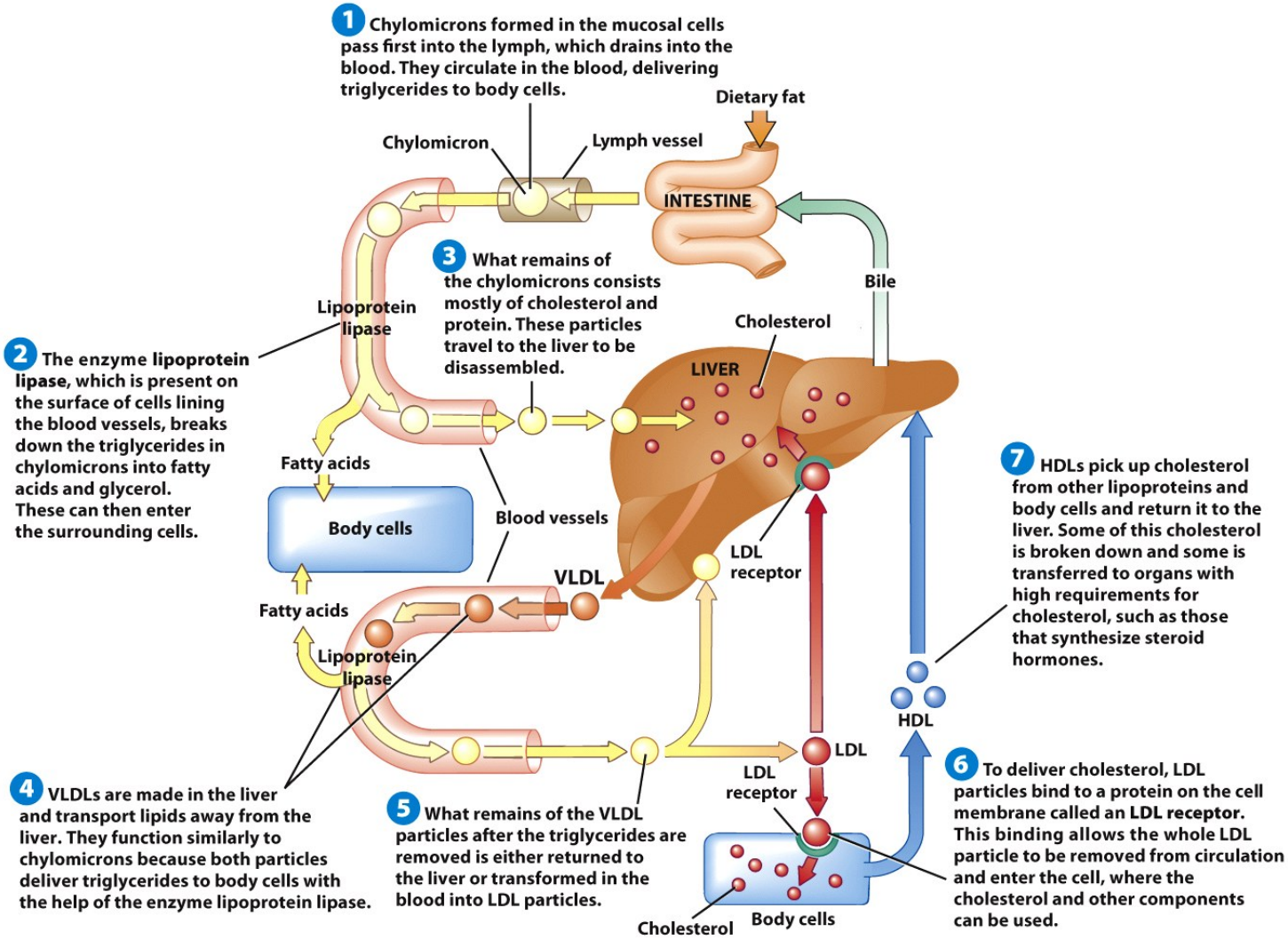
Very low density lipoproteins (VLDL)

- VLDL particles are made in the liver
- VLDL particles function similar to chylomicrons (transport triglycerides which are broken down by lipoprotein lipase)
  - Remainder of VLDL particles are returned to the liver or made into LDL particles

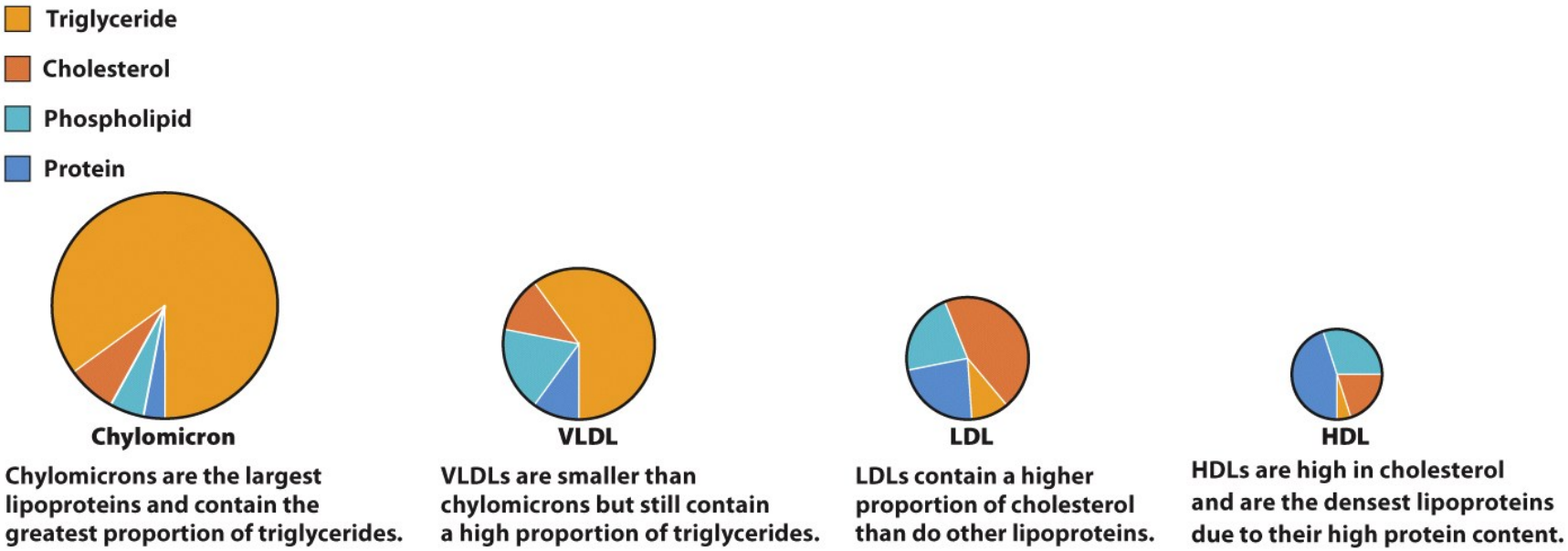
Low density lipoproteins (LDL)

- LDL particles deliver cholesterol to cells
- LDL particles bind to LDL receptors on cells to help cholesterol move from the blood into cells

Low density lipoproteins (LDL)



Low density lipoproteins (LDL)



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High density lipoproteins (HDL)

- HDL particles transport cholesterol from cells to the liver
- The liver uses cholesterol to make bile acids

Bile

- Bile is stored in the gall bladder before entering the small intestines
- Bile emulsifies (breaks up larger particles) dietary fat so it is more accessible to lipases (lipid-digesting enzymes)
- Dietary fiber binds cholesterol to keep it from being reabsorbed into the body from the small intestines (so more is excreted from the body)

How to Decrease your LDL and Increase HDL

- Decrease dietary *trans*-fat, saturated fat, and cholesterol
- Increase dietary polyunsaturated fats and monounsaturated fats
- Quit smoking // Exercise
- Improve social relationships

LDL vs. HDL

- LDL particles transport cholesterol from the liver to body cells
  - Work to decrease your blood levels of LDL // ("you want your low to be low")
- HDL particles transport cholesterol from body cells to the liver so they can be excreted
  - Work to increase your blood levels of HDL // ("you want your high to be high")

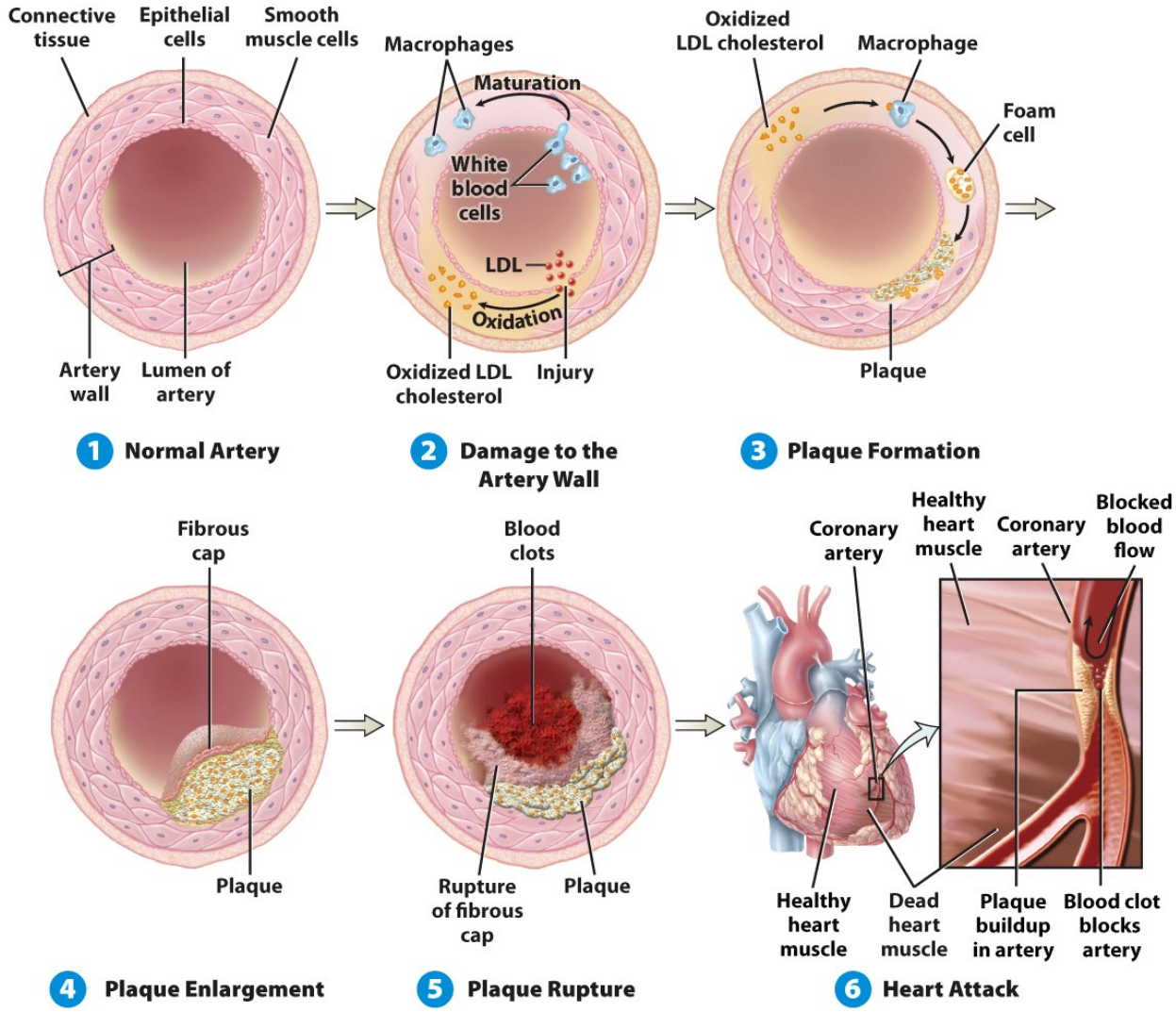
Lipoproteins are blood transport particles

- We do not eat LDL and HDL / produced by liver
- Dietary lipids (such as cholesterol and triglycerdies) are packaged into lipoprotein particles (such as LDL and HDL) for transport in blood

LDL is "lethal"

- Blood vessel injury, inflammation and LDL oxidization generates plaques blood vessel walls in atherosclerosis
  - Antioxidants (found in fruits and vegetables) can limit oxidation of LDL
- Atherosclerosis can narrow blood vessels and limit blood flow to tissues so that fewer nutrients and oxygen molecules are delivered

Atherosclerosis development



Atherosclerosis can lead to heart attacks and strokes

- Atherosclerosis plaques can break through the blood vessel walls and stimulate clot formation to completely block blood flow
- In the heart, this causes heart attacks (also called myocardial infarctions, or MIs)
- In the brain, this causes strokes (also called cerebral vascular accidents, or CVAs)

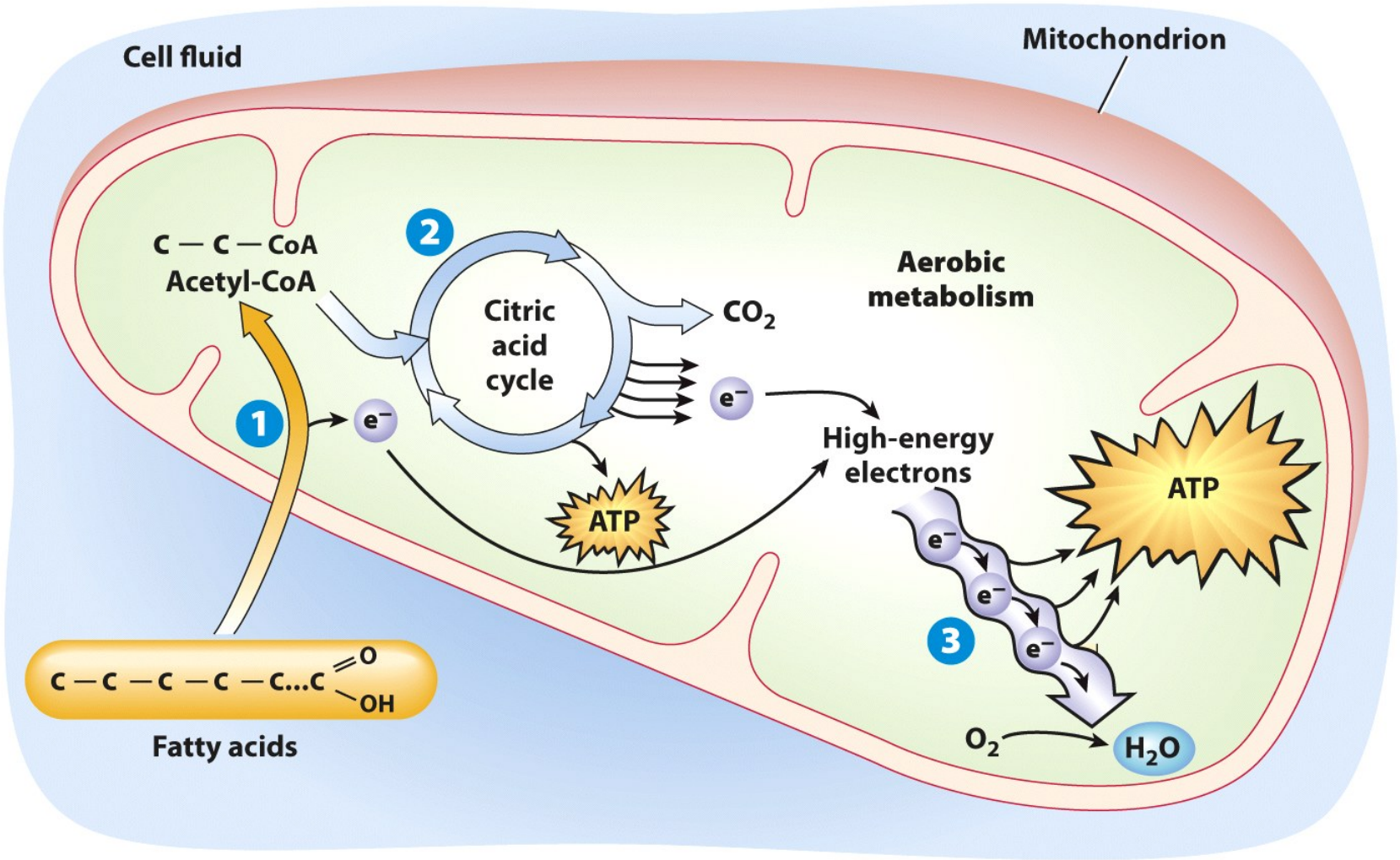
Risk factors for atherosclerosis and cardiovascular disease

- Poor diet
- Smoking
- Diabetes
- High blood pressure (hypertension)
- Obesity
- Sedentary
- Blood lipids (high LDL, triglycerides; low HDL)
- Family history, age, gender, race

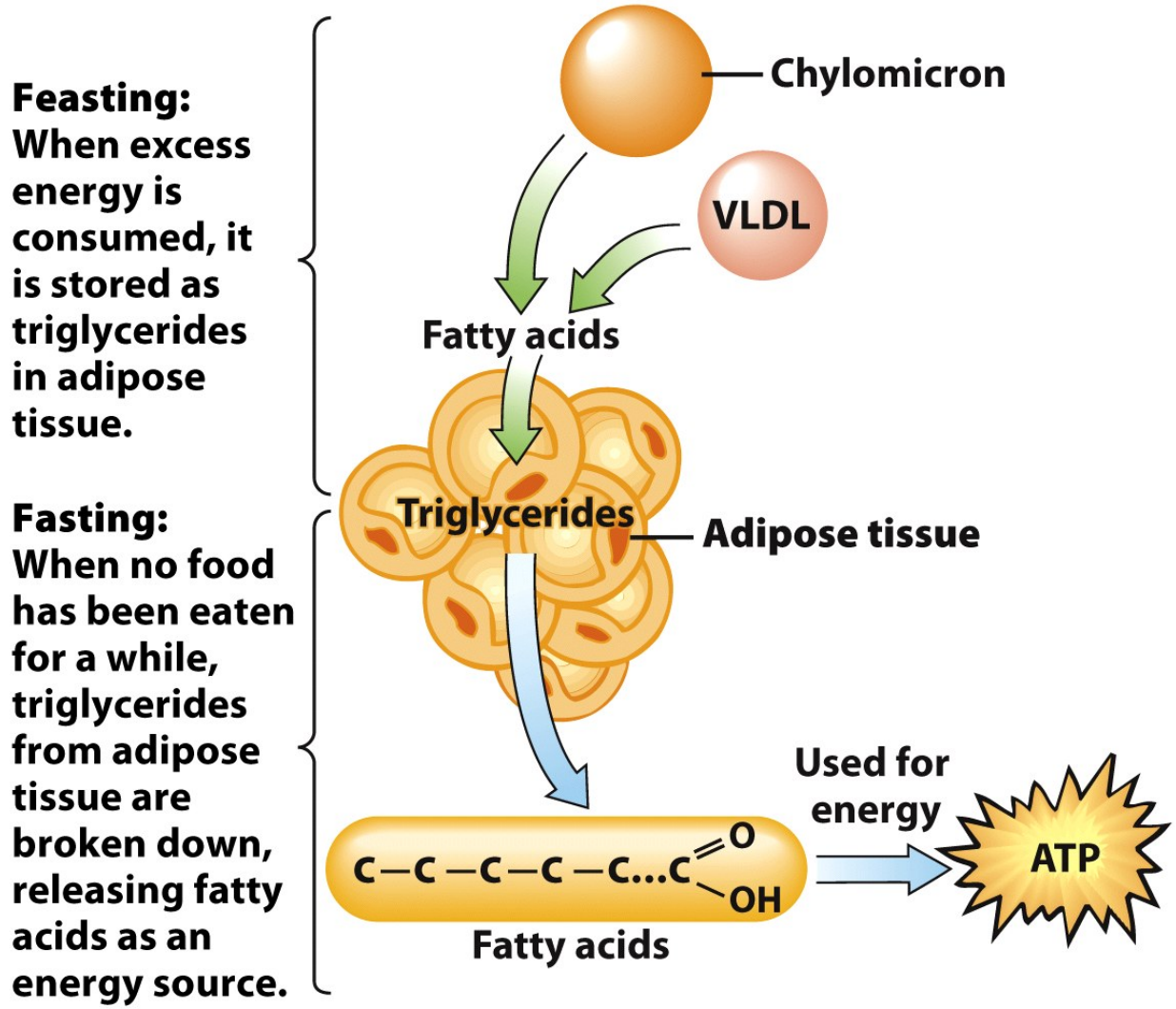
Benefits of lipids/fats

- Provide texture, flavor, aroma to foods
- Phospholipids and cholesterol are in membranes and are starting materials for other molecules
- Help absorb fat-soluble vitamins
- Light-weight, long-term storage of energy
- Insulation, cushion, lubricant

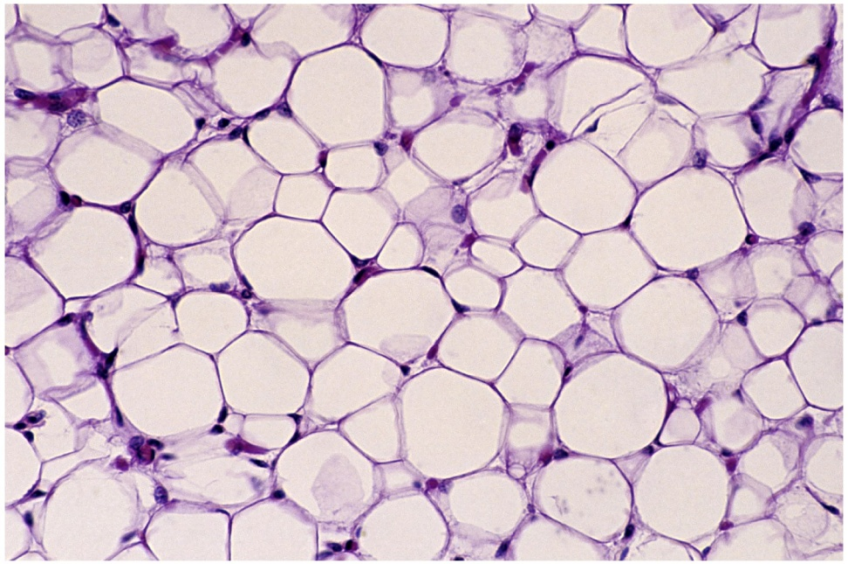
Conversion of fatty acids to energy



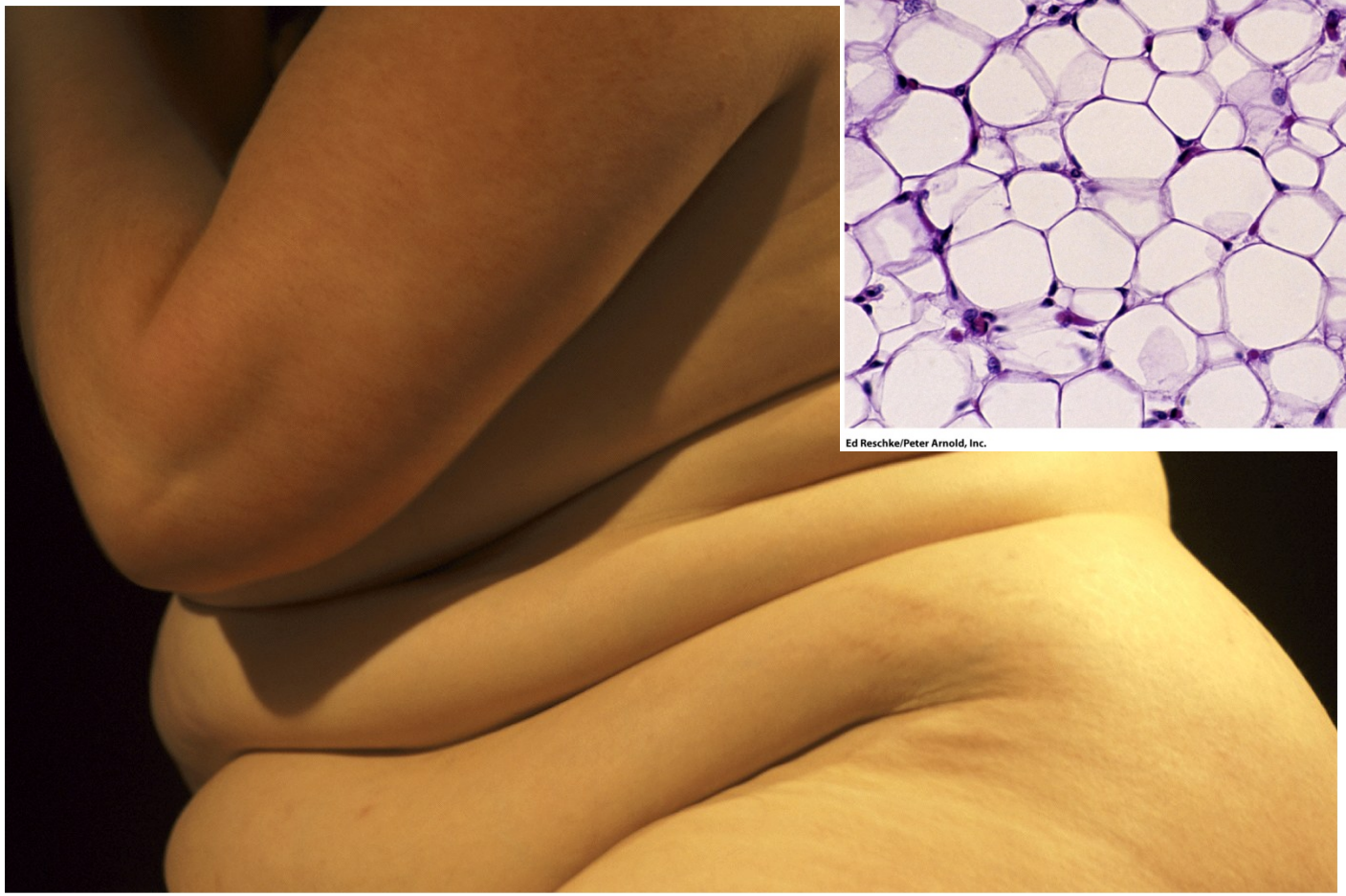
Feasting vs. fasting



Storage of excess fatty acids



Ed Reschke/Peter Arnold, Inc.



Karen Kasmauski/NG Image Collection

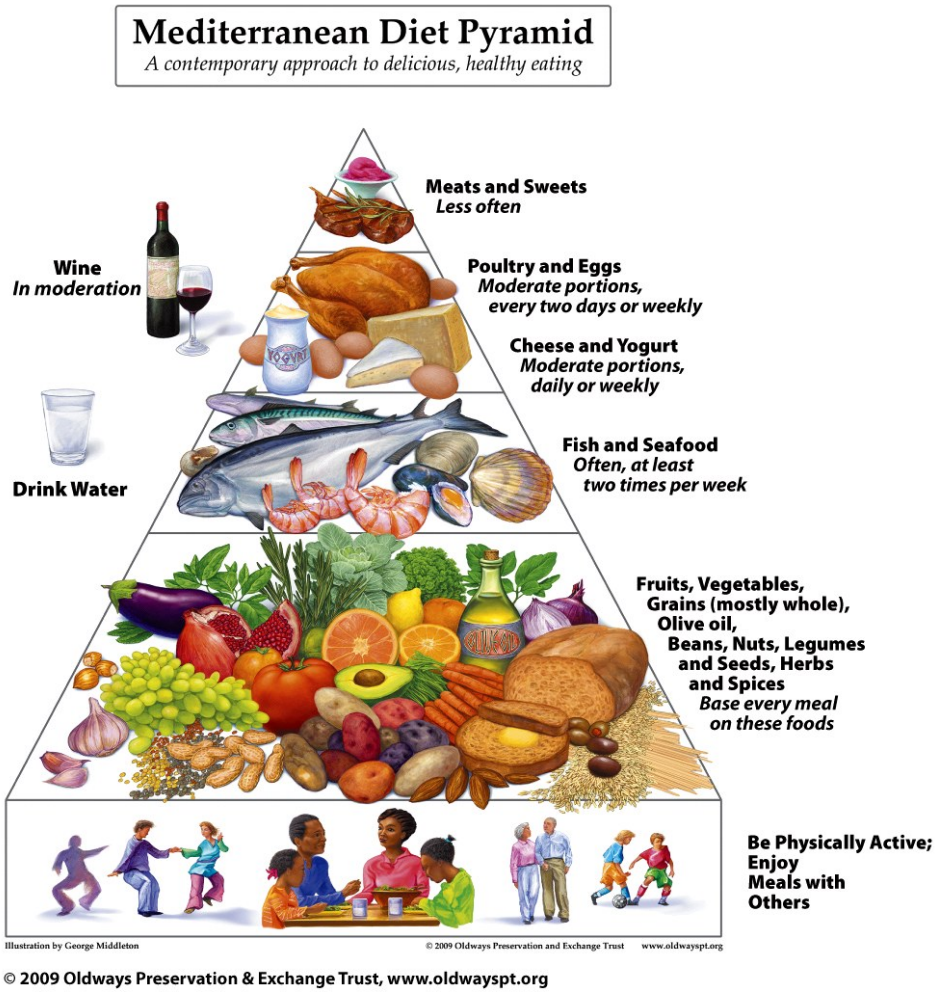
Dietary fat and obesity

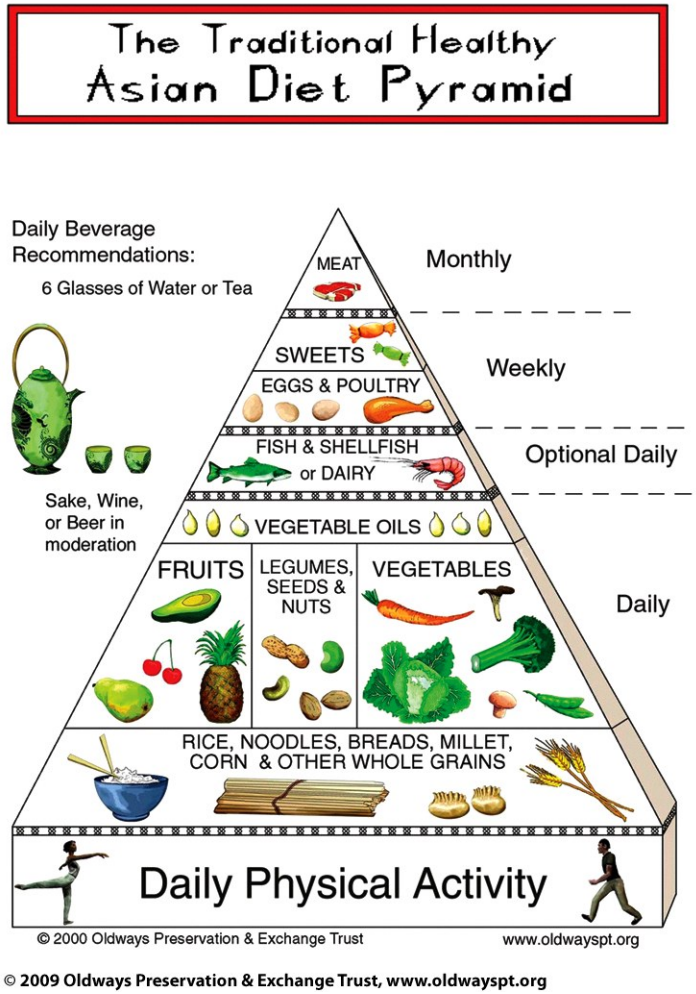
- Fat has 9 calories per gram
- Carbohydrates & proteins have 4 calories per gram
- Fat is efficiently stored
- A little to much “fatty food” provides a great many calories!

Dietary recommendations

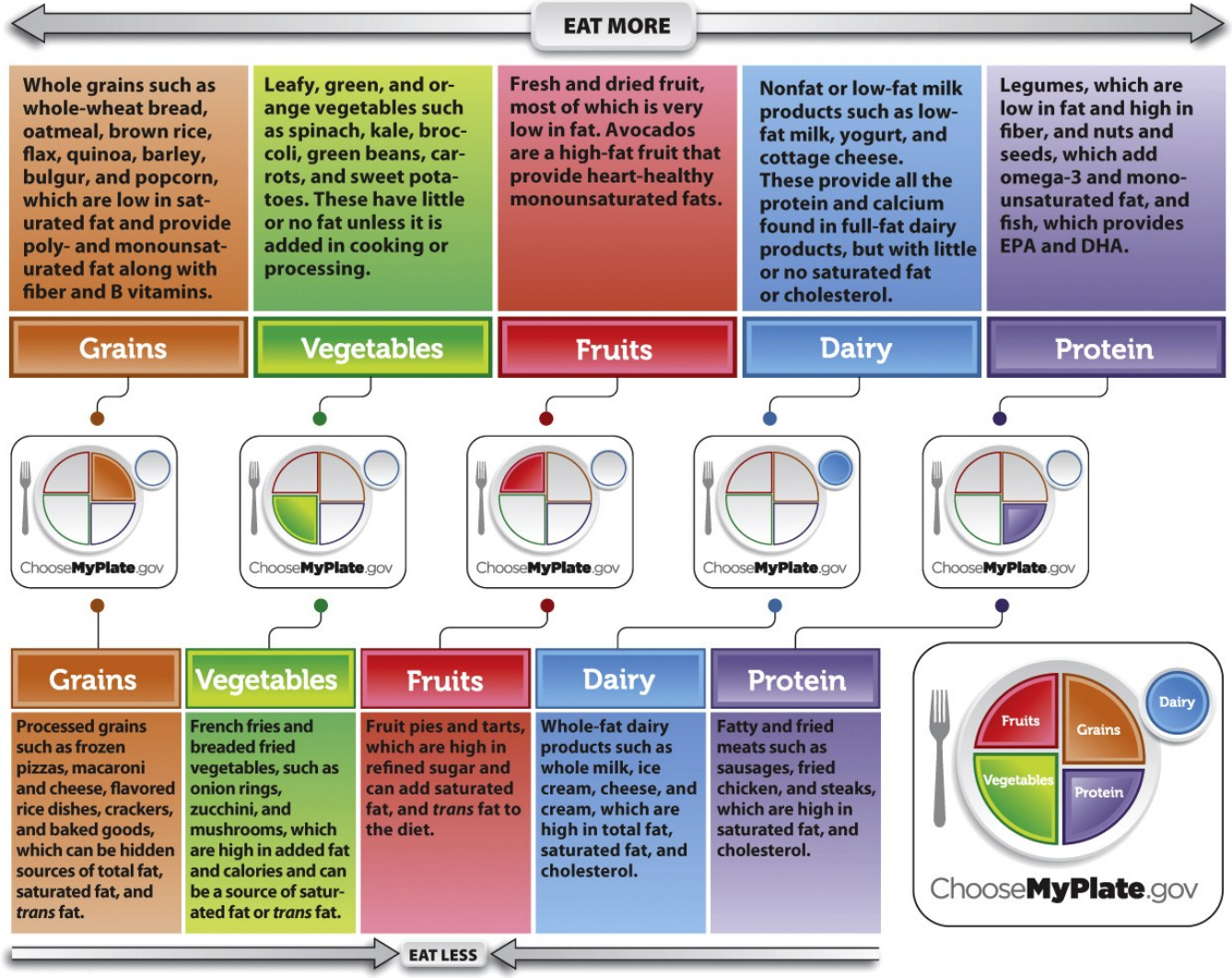
- Total fat: 20%–35% of total calories
  - 30–40% for ages 1–3 & 25–35% for ages 3–18
- Saturated fat: less than 7% of total calories
- Cholesterol: less than 300 mg per day
- *Trans*-fat: limit

Mediterranean and Asian diets may decrease cardiovascular disease





MyPlate Choices



U.S. Department of Agriculture, http://www.choosemyplate.gov/tipsresources/printmaterials.html

Food labels

Chocolate Chip Cookies

Nutrition Facts
Serving Size 3 Cookies (33g)
Servings Per Container About 13

Amount Per Serving	
Calories 160	Calories from Fat 70
	% Daily Value*
Total Fat 8g	12%
Saturated Fat 3g	15%
Trans Fat 0g	
Polyunsat Fat 2.5g	
Monounsat Fat 2g	
Cholesterol 0mg	0%
Sodium 110mg	5%
Potassium 45mg	1%
Total Carbohydrate 22g	7%
Dietary Fiber Less than 1gram	3%
Sugars 11g	
Protein 2g	

Vitamin A 0%	•	Vitamin C 0%	
Calcium 0%	•	Iron 4%	

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Potassium	Less than	3,500mg	3,500mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

INGREDIENTS: ENRICHED FLOUR (WHEAT FLOUR, NIACIN, REDUCED IRON, THIAMINE MONONITRATE (VITAMIN B1), FOLIC ACID, SEMISWEET CHOCOLATE CHIPS (SUGAR, CHOCOLATE, COCOA BUTTER, DEXTROSE, SOYLECITHIN AN EMULSIFIER), SUGAR, SOY BEAN OIL AND/OR PARTIALLY HYDROGENATED COTTONSEED OIL, HIGH FRUCTOSE CORN SYRUP, LEAVENING (BAKING SODA AND/OR AMMONIUM PHOSPHATE), SALT, WHEY (FROM MILK), NATURAL AND ARTIFICIAL FLAVOR, CARAMEL COLOR.
CONTAINS: WHEAT, SOY, MILK

The Nutrition Facts panel lists Calories from fat; grams of total fat, saturated fat, and *trans* fat; and milligrams of cholesterol in a serving. The amount of monounsaturated and polyunsaturated fat is voluntarily included on the labels of some products.

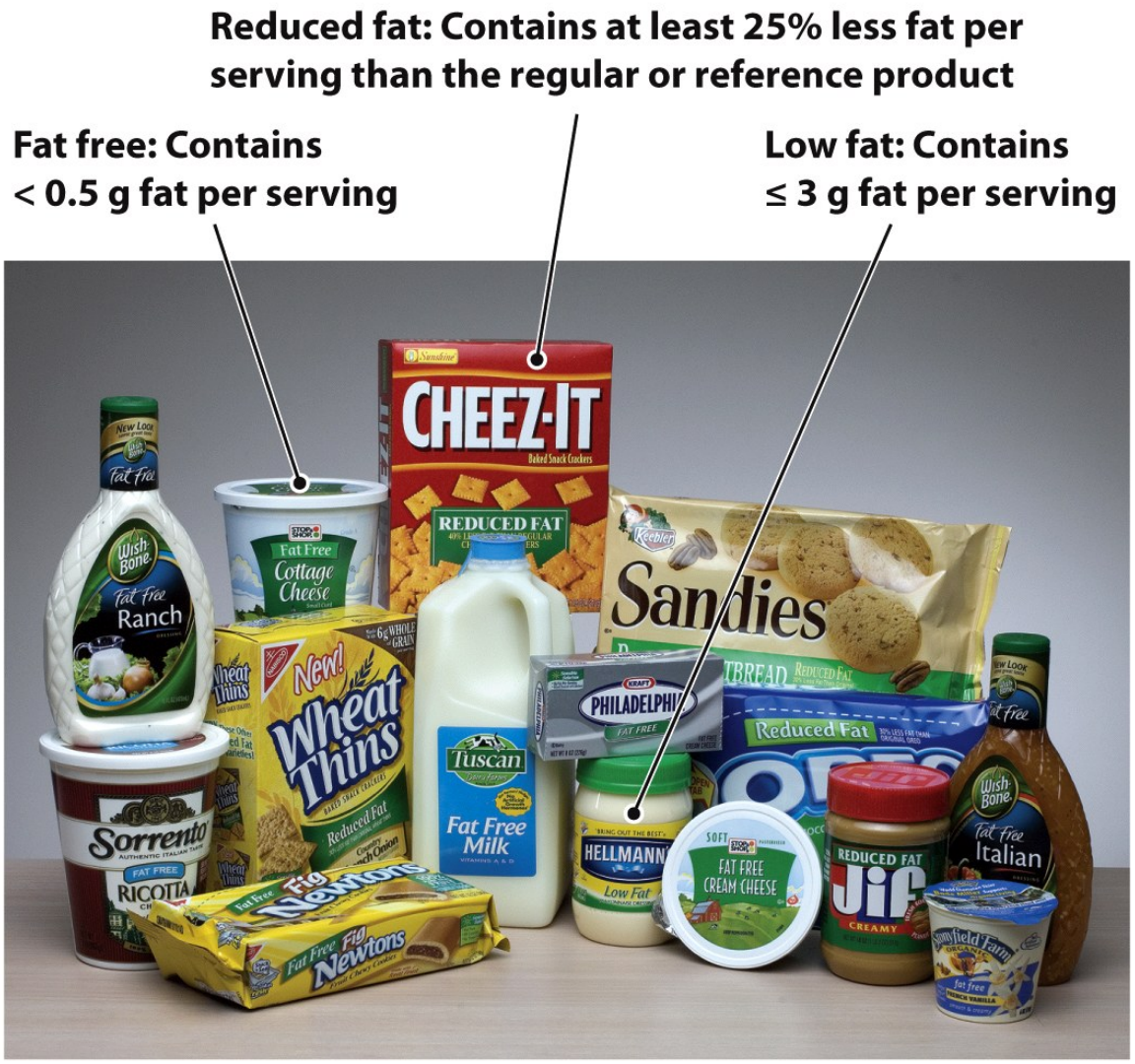
A % Daily Value is listed for total fat, saturated fat, and cholesterol. This allows consumers to tell how a food fits the recommendations. Generally, ″ 5% of the Daily Value is low, and ≥20% is high. There are no Daily Values for *trans*, polyunsaturated, and monounsaturated fats.

If the product has less than 0.5 gram of *trans* fat per serving, the nutrition facts panel will list the amount of *trans* fat as 0, even if partially hydrogenated oil is an ingredient.

The Daily Values recommend consuming less than 30% of calories as fat, no more than 300 mg of cholesterol per day, and no more than 10% of calories as saturated fat. It is recommended that *trans* fat intake be limited to the amounts present naturally in meats and dairy products (″ 0.5% of calories).

The sources of fat in a product are listed in the ingredient list with the other ingredients, in order of prominence by weight.

Food labels



Andy Washnik

Fat replacers

The artificial fat Olestra (sucrose polyester) is made from sucrose with fatty acids attached. Olestra cannot be digested by either human enzymes or bacterial enzymes in the gastrointestinal tract. Therefore, it is excreted in the feces without being absorbed.

Polysaccharides such as pectins and gums are often used in baked goods, as well as salad dressings, sauces, and ice cream, to mimic the texture that fat provides. They reduce the amount of fat in a product and at the same time add soluble fiber.

The sugar sucrose is usually added to low-fat and nonfat baked goods to improve flavor and add volume. Sucrose adds 4 Calories per gram.

Protein-based fat replacers are made from milk and egg proteins processed to form millions of microscopic balls that slide over each other, mimicking the creamy texture of fat.[34] They are used in frozen desserts, cheese foods, and other products but cannot be used for frying because they break down at high temperatures.

Andy Washnik

Review Questions

- Use these slides to access your knowledge and prepare for the unit exam.

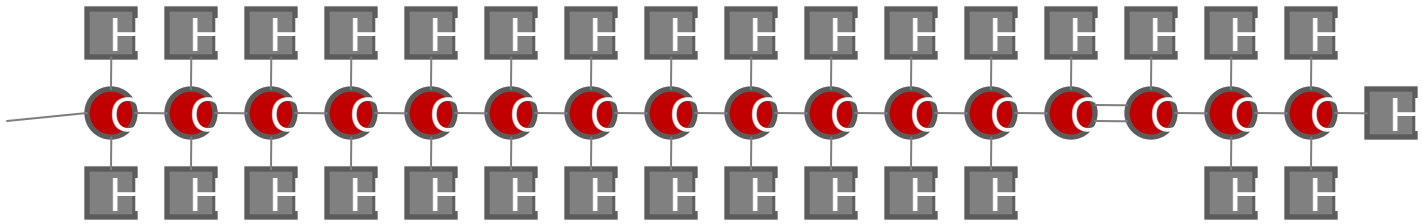
Concept check

What are similarities and differences between:

- saturated and unsaturated fats?
- monounsaturated and polyunsaturated fats?
- omega-3 and omega-6 fats?
- *cis*-fats and *trans*-fats?

Which of the following is a saturated fatty acid?

1)



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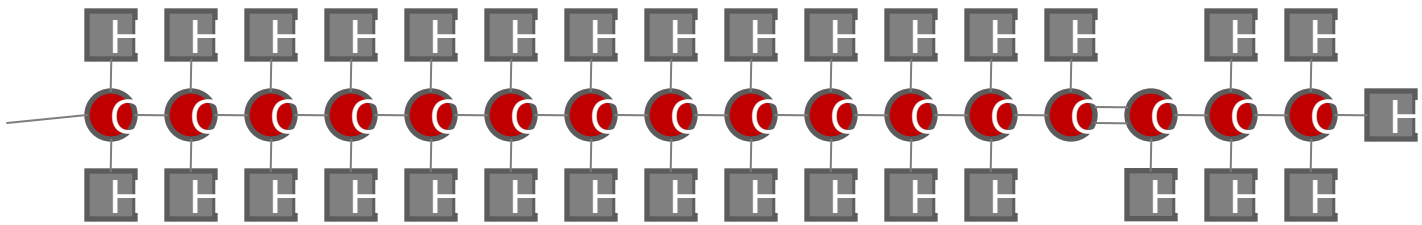

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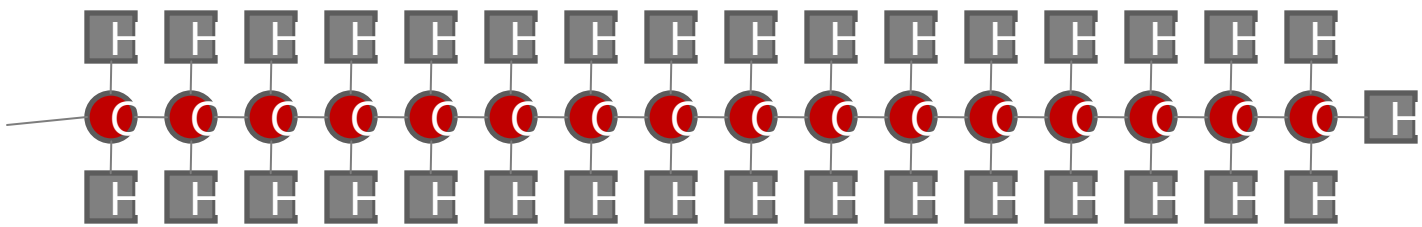
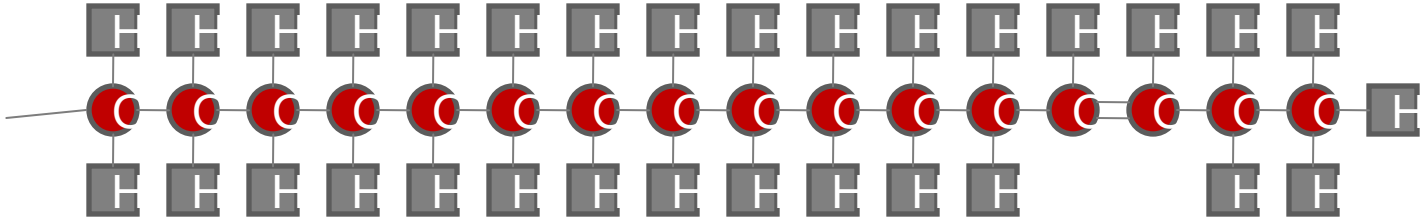


Which of the following is a polyunsaturated fatty acid?

1)



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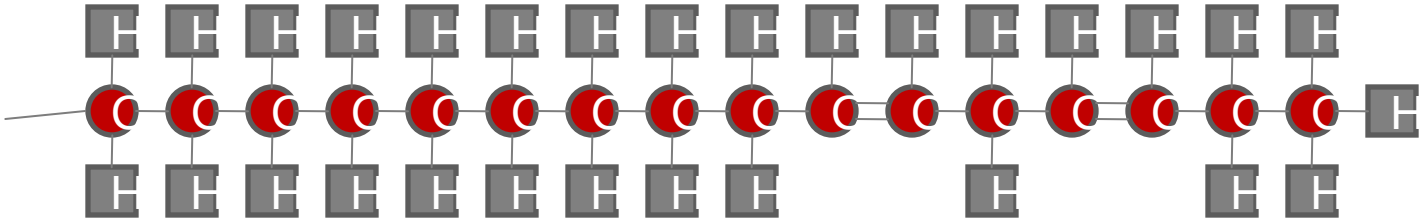

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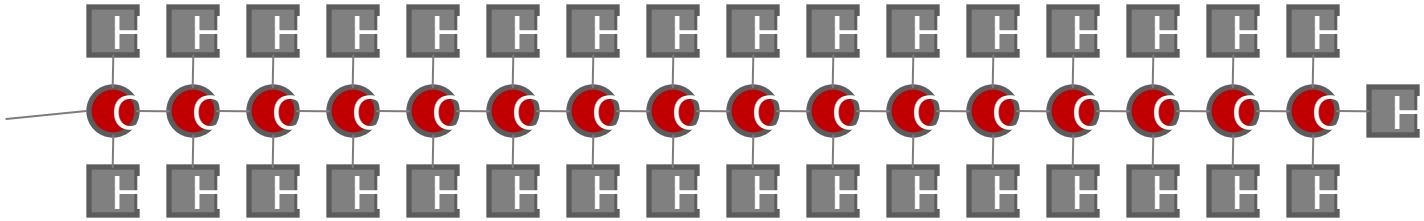
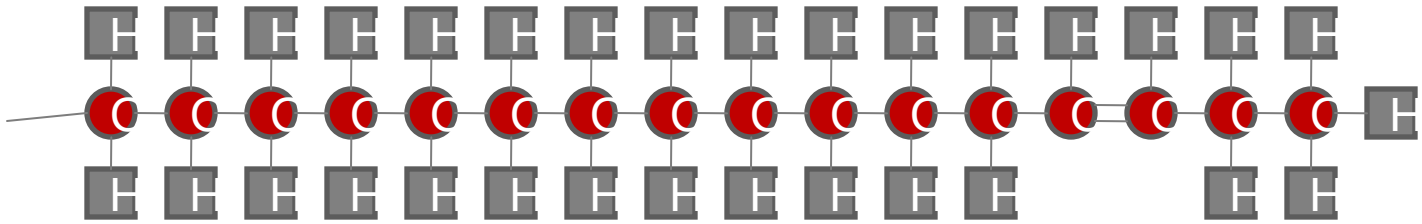


Which of the following is an omega-6 fat?

1)



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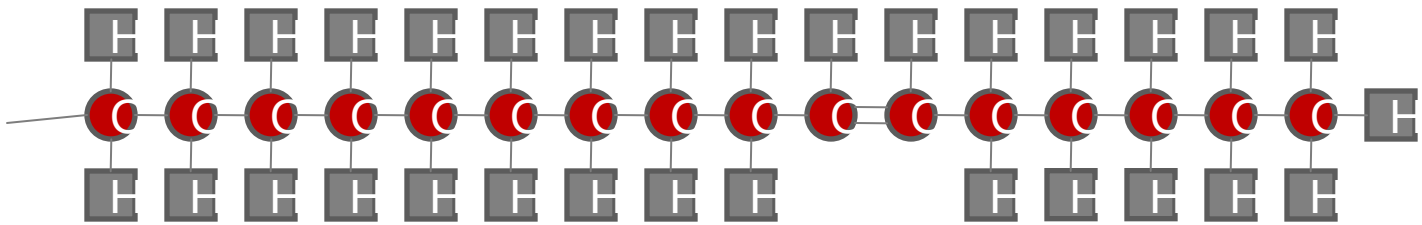

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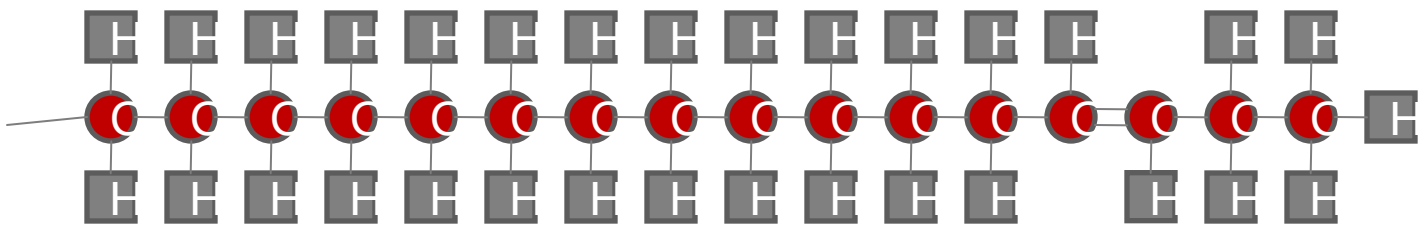
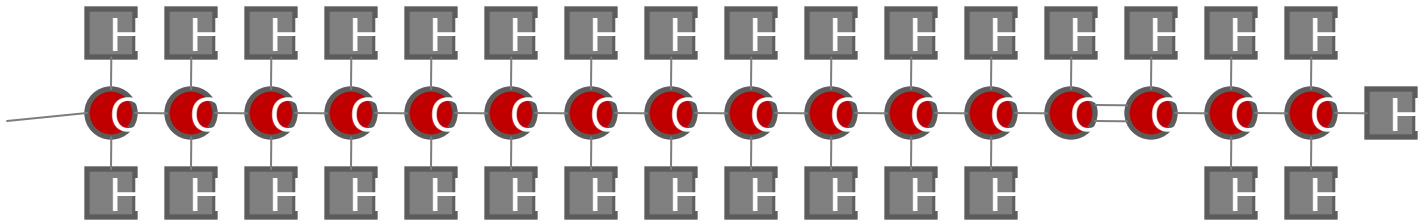


Which of the following is a *trans* fat?

1)



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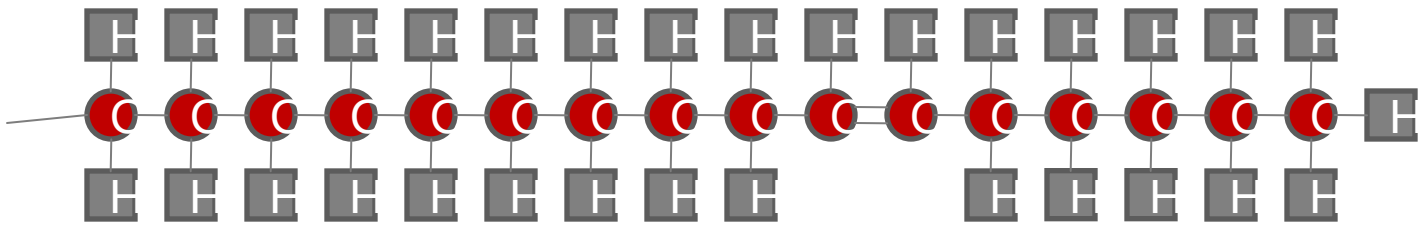

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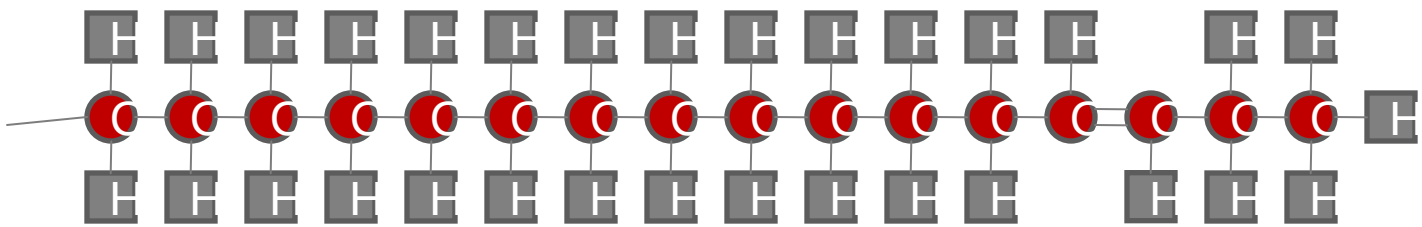


Trans-fat in the news

- Margarine vs. butter
- *Trans*-fat added to nutrition facts panel (2006)
- *Trans*-fat bans (for example, New York City)

Debate the issues

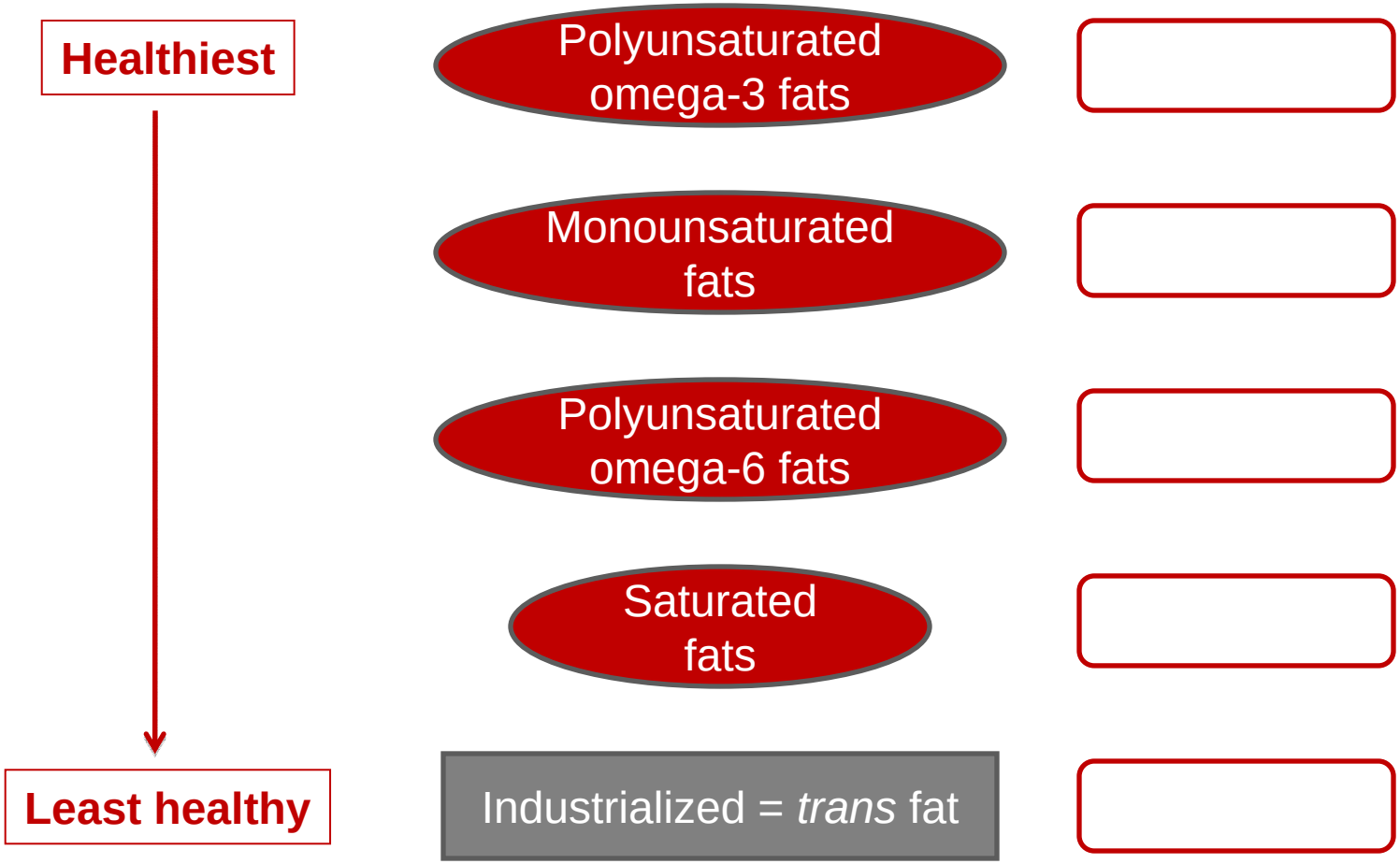
- Should the government pass additional *trans*-fat bans?
- Should unhealthy foods such as soda and potato chips have an additional tax?

Concept check

- Americans consume too much saturated fat and too few omega-3 fats.

- What dietary recommendations could be made to help them improve their diets?

Which fat sources can you increase and limit to improve your fat intake?



Concept check

To improve health, consume:

1. more animal fat
2. more monounsaturated fat
3. less omega-3 fat
4. less plant fat

Concept check

- How are phospholipids and cholesterol similar and different?
- What is an example of a non-essential nutrient?

Concept check

- If a person does not have LDL receptors, what would you expect to happen to blood levels of LDL?

- What are examples of foods you can limit and increase to lower your LDL and raise your HDL?

Checking student learning outcomes

- What are the benefits and risks of dietary fats?
- How are fats classified? What are the similarities and differences between types of fat?
- Which foods should be consumed and avoided to improve health?

Concept check

Which of the following is true?

1. Cholesterol is made in the small intestines.
2. Bile is packaged into HDL particles.
3. HDL is oxidized during atherosclerosis.
4. LDL delivers cholesterol to cells.

Concept check

- What are some benefits of lipids/fats discussed so far?

Concept check

- What are benefits and dangers of limiting fat intake?
- What are the dangers of consuming too much fat?

Concept check

- Which dietary and lifestyle changes can you make to decrease your risk of atherosclerosis and cardiovascular disease?

Concept check

- What are some benefits of diets rich in fruits and vegetables?
- What are some consequences of diets high in animal fats?