

# Fats & Fatty Acids

## Function of Fats

- Store energy (typically stored in the form of triglyceride fat molecules, shown on next page)
- Burn for energy (energy content is 9 Cal/g)
- Fatty acids are components for building certain cell components, including cell membranes and hormone molecules

**The energy content of fat is 9 Cal per gram.** (compared to 4 Cal/g for carbohydrates or protein)

- Fats have less oxygen than carbohydrates; organic molecules with less oxygen tend to store more energy, because C-H is a higher energy bond than C-O.

## Fat Nutrition

- 30% or less of your total Calories should be from fat (i.e. total fat)
- 10% or less of your total Calories should be from saturated fat (1/3 of your total fat: 10% vs 30%)
  - This amount is included in the recommended 30% from fat, not in addition to it.
  - The American Heart Association recommends less than 7%.
- 1% or less of your total Calories should be from trans fat
  - Some organizations state that no level of trans fat consumption is safe
- 1 g of fat = 9 Cal

**Example:** If your recommended energy intake is 2700 Calories per day, what is your recommended maximum grams of fat per day?

**Answer part 1:**

- 30% of 2700 Cal is **810 Cal**. So you should get 810 Cal (or less) from fat out of your total of 2700.

Now, how many grams of fat would give you 810 Cal?

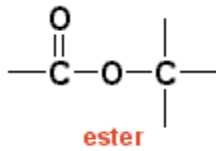
**Answer part 2:**  $810 \text{ Cal} \div 9 \text{ Cal/g} = \mathbf{90 \text{ g of fat}}$  (see above: each gram of fat provides 9 Cal)

**Essential Fatty Acids:** Fatty acids that the body cannot make on its own. They must be eaten in food. (the body can make most fatty acids from carbs or other fatty acids)

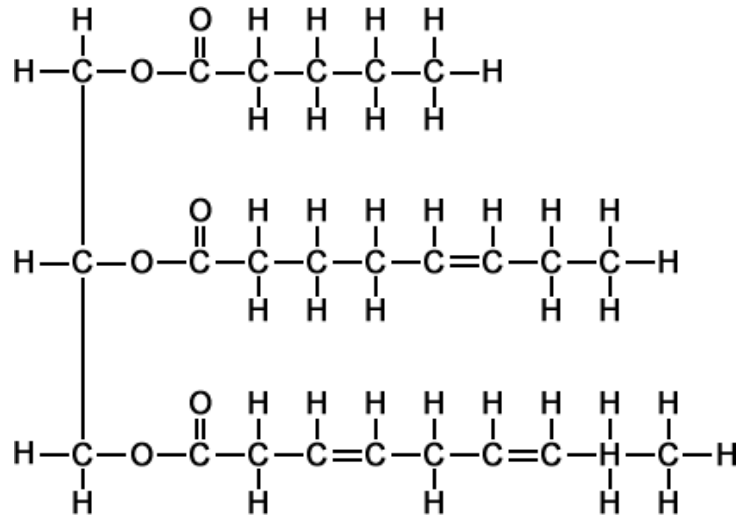
- Required for muscle growth, used in the brain, used in cell phospholipid membranes, hormonal signaling, inflammation signals, and other functions.
- Omega-3 / Omega-6: families of acids with a double bond at the 3<sup>rd</sup> or 6<sup>th</sup> carbon from the end. They are found in fish oils, flaxseed oil, olive oil, chicken, eggs, avocado, nuts, and various other oils.
- The essential fatty acids are unsaturated fatty acids (explained below).
- Cells can synthesize most of the fatty acids we need out of carbohydrates and protein.
  - Therefore, we only need a small amount of fat in our diet to survive
  - There is no minimum RDA (Recommended Dietary Allowance) for total fat. Only a maximum recommended amount.
  - No saturated fat is required for a healthy diet. (saturated fats explained below)

## Fats and Fatty Acids

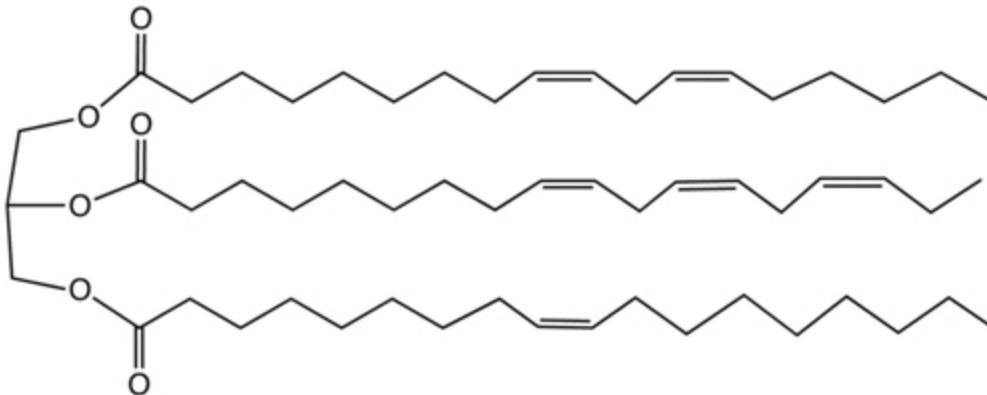
Fats have ester functional groups.



**Example fat molecules:** the following two diagrams each show a triglyceride molecule, which is a fat molecule with three separate ester groups. (C-O-C=O group is an ester functional group).

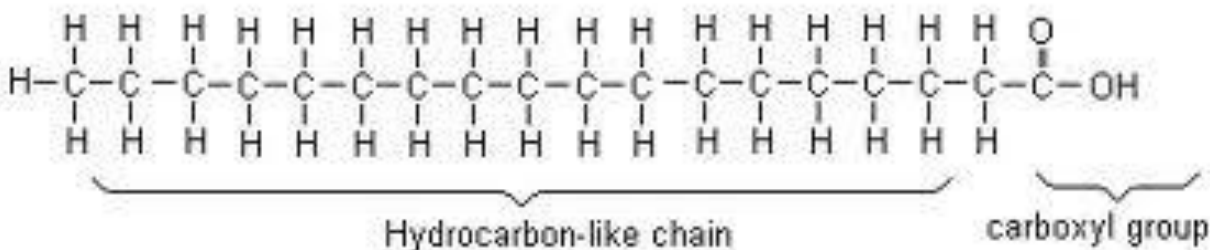


This first diagram shows a structural formula, which displays each carbon and hydrogen atom. The next diagram is a “stick diagram;” in this type of diagram, each point is a carbon unless otherwise labeled, and hydrogen atoms are not shown. In both cases, three ester groups are present.



**Fatty Acids:** they react to form fats. Fatty acids have carboxylic acid functional groups.

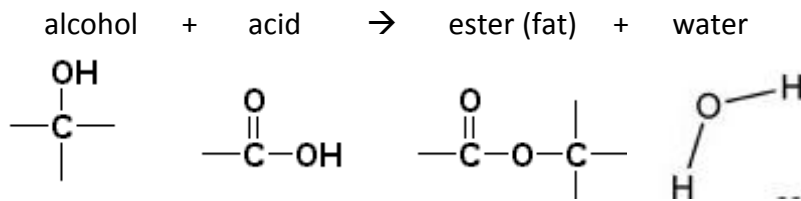
**Example:** Stearic Acid



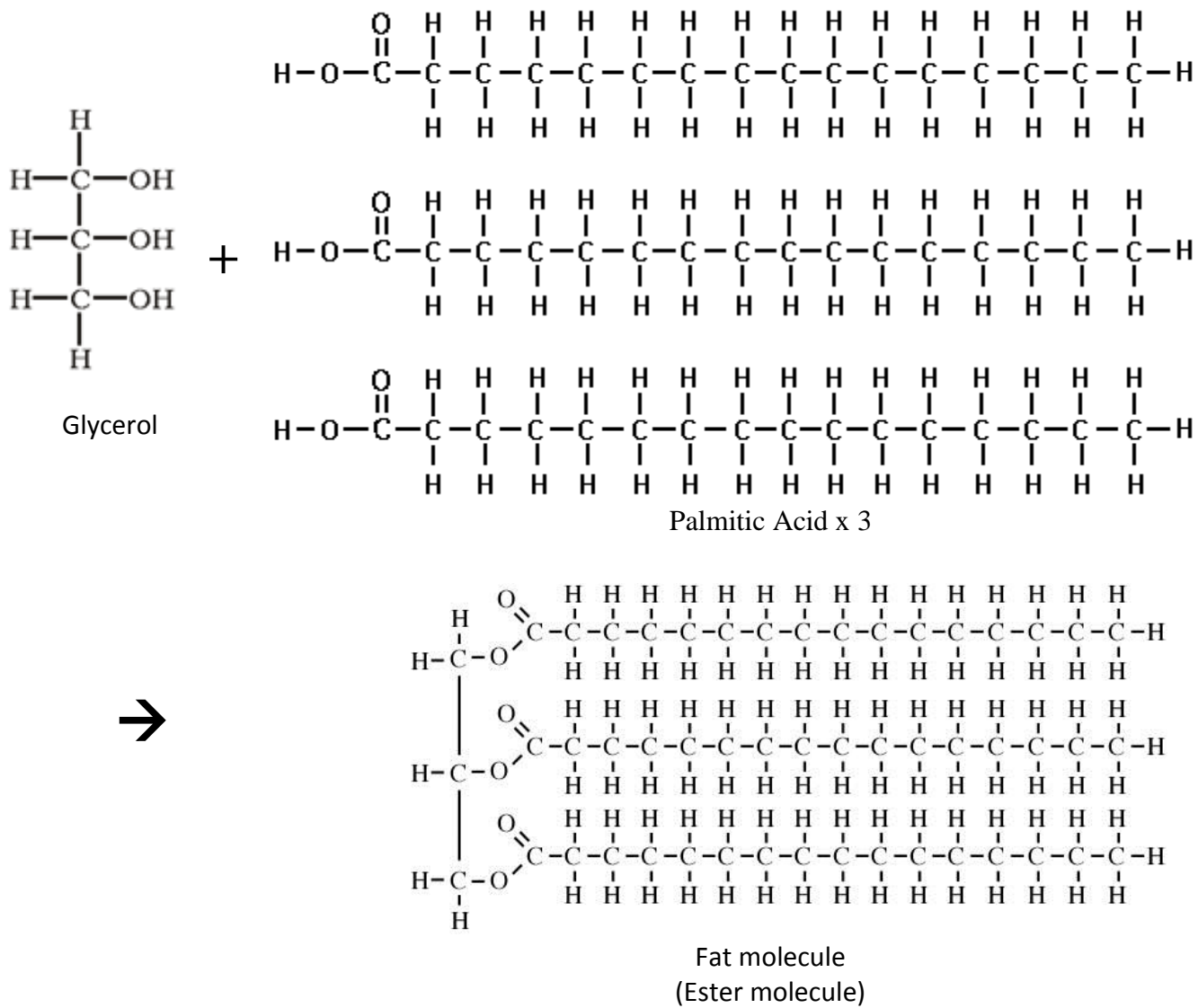
(a “carboxyl group” is the same as a “carboxylic acid” group)

## Formation of Fat Molecules

Fats are produced through the following general reaction. This shows only the functional groups involved, not the entire molecules.



In a typical case, the alcohol will be glycerol, an alcohol molecule with three C-OH groups. That can combine with three free fatty acids to form a fat molecule (a triglyceride in this case). The following shows the full molecules involved in a fat reaction. Notice that most of the molecules are made of up C-C single bonds, so most of the molecule is an alkane chain. After you eat a meal, you will have fatty acids in your blood from the food. If you have extras available that aren't needed for immediate energy, your body stores those fatty acids as fat molecules.

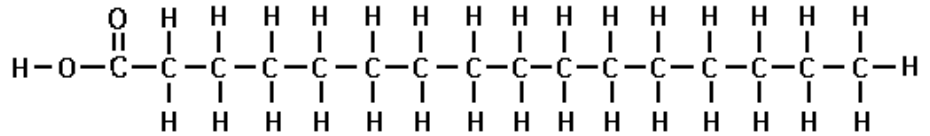


This process can also be reversed. That is what happens when your body breaks down fats to burn the fatty acids for energy.

## Types of Fatty Acids

### Saturated Fatty Acids

- Has no alkene groups (no C=C bonds)
- Has a carboxylic acid group



Example saturated fatty acid: palmitic acid  
(the most common saturated fatty acid)

### State

- Solid at room temperature
  - Single bond carbon chains pack together closely, so density and melting point are higher

### Health Info:

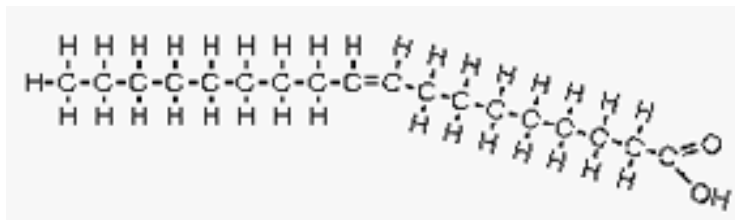
- Unhealthy type of fat
  - Increases LDL (bad cholesterol)
  - Increase risk of cardiovascular disease

### Foods Containing Saturated Fatty Acids:

- Found especially in animal products
  - Meats, butter, cheese, cream, milk (note that these are all solid fats)

### Unsaturated Fatty Acids

- Has at least one alkene group
- Has a carboxylic acid group



Example: Oleic Acid (lots of oleic acid in olive oil)

### State

- liquid at room temperature
  - C=C double bonds bend the carbon chain, so they don't pack as efficiently – intermolecular forces are lower, density is less, and melting point is lower.

### Health Info:

- Healthy type of fat
  - **Not all fats are unhealthy!**
  - Increases HDL (good cholesterol)
  - Some types of unsaturated fats are essential, meaning your body can't make them and you have to eat some in your diet in order to get enough for your cells.

### Foods Containing Unsaturated Fatty Acids:

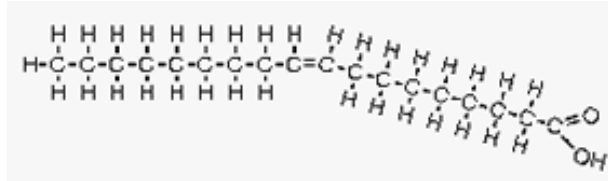
- Found especially in plant products
  - Vegetable oil, olive oil, peanut oil, canola oil, sunflower oil, etc
  - Nuts contain lots of fats, often unsaturated fats
  - Avocado is high in unsaturated fats

## Types of UNSATURATED Fatty Acids

Following are three subcategories of unsaturated fatty acids

### **Monounsaturated Fatty Acids**

- Has one alkene group (“mono” means “one”)
- Has a carboxylic acid group



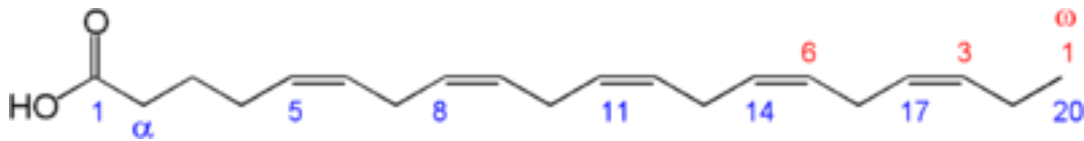
Example monounsaturated fatty acid: oleic acid

### **Health Info:**

- Healthy type of fat
  - Probably has the biggest positive effect on cholesterol

### **Polyunsaturated Fatty Acids**

- Has more than one alkene group (“poly” means “many”)
- Has a carboxylic acid group



Example: EPA (eicosapentaenoic acid)  
(EPA is an “omega-3” fatty acid)

### **Health Info:**

- Healthy type of fat
  - Some polyunsaturated fats are essential, meaning your body can't make them and you have to eat some in your diet in order to remain healthy.
  - “Omega-3” fats are especially healthy essential fatty acids (good for cholesterol)
    - Found especially in fish – this is why people take fish oil supplements

### **Trans Fatty Acids**

- An unnatural, very unhealthy form of unsaturated fat (note: natural unsaturated fats are healthy)
- Even small amounts can cause health issues over time.
- Found in some processed foods (those that contain **partially hydrogenated** oils).
- Not typically found in natural foods
  - Exception: beef has naturally occurring trans fat
  - Unknown whether natural trans fats are any healthier than synthetic trans fat

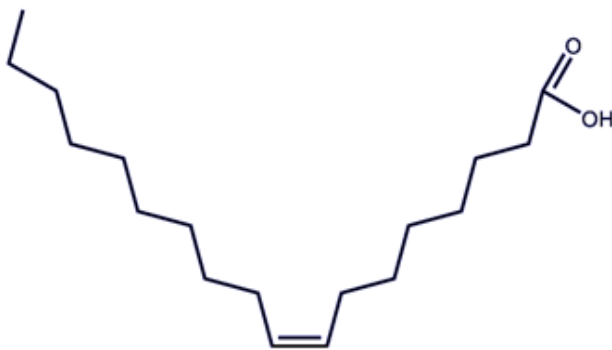
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## Trans Fatty Acids – Health Effects

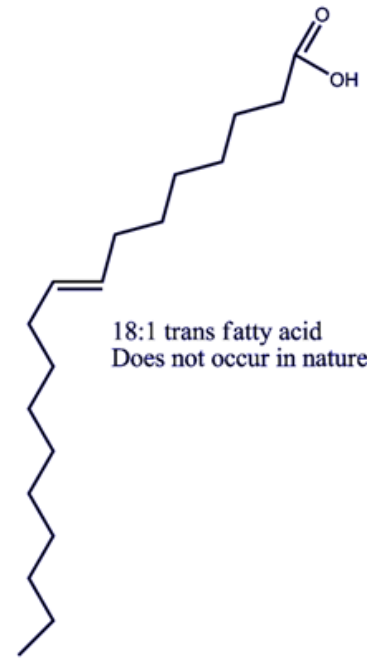
- Trans fatty acids are **very unhealthy** unsaturated fatty acids. (confusing since normal unsaturated fats are healthy)
- Strong evidence that trans fat increases bad cholesterol (LDL) and decrease cholesterol (HDL)
  - Causes coronary artery disease
- Some limited evidence suggests that trans fat may contribute to a number of other serious problems
  - Cancer, diabetes, Alzheimer's, obesity, liver dysfunction, infertility, depression
- Small amounts of trans fats (even 2 grams per day) have a significant health impact

## Chemistry of Trans Fats

- Normal, natural unsaturated fats are “cis” fats. This means that on their double bonds, the carbons both come out of the same side of their double bonds.
- “Trans” fats have their carbon chains coming out opposite sides of their double bonds.
- This small difference causes the fatty acid molecules to be shaped differently, which affects the way they behave in our cells.
- The fats below have the same formula and have the double bond in the same place, but they are isomers of each other since one is *cis* and one is *trans*.
- Don't stress over the chemistry; this is just in case you're curious.



18:1 cis fatty acid  
A natural fatty acid



18:1 trans fatty acid  
Does not occur in nature

## Where Trans Fats are Found

- Found in partially hydrogenated oils. These are chemically processed oils.
  - examples: vegetable shortening, some oils used for deep frying
  - Found in packaged baked goods, doughnuts, candy bars, and other processed foods
  - Foods in restaurants often contain trans fats
  - Naturally occurring in beef fat
- Even if your food's label shows 0 grams of trans fat per serving, it can have up to 0.49 g of trans fat.
- Check the ingredients: if it has any partially hydrogenated oils, it contains trans fat.
- According to the National Academy of Sciences, there is *no safe level* of trans fat consumption.
- The American Heart Association recommends getting less than 1% of total Calories from trans fat
- Natural foods do not contain trans fats, except for small amounts found in dairy and beef.