

Fatty Acids, Nutrition and Health:

Students please note: It is assumed that you have an understanding of organic molecules as presented in your text book. If not, you should read chapter 3 in your text book dealing with organic molecules. At a minimum, you need to look over the sections associated with lipids. At the end of the scenario, there are some links listed to web sites that you might find useful.

Its time for your annual physical examination...

Suppose that you were visiting your doctor for an annual physical examination. While you were in the waiting room, you picked up and began to read a pamphlet about dietary fats (lipids) and their impacts on health. In order to remember them later, you typed some of the important points into a file on your laptop. To refresh your memory, and for your convenience (and the rest of the class), these notes can be seen below.

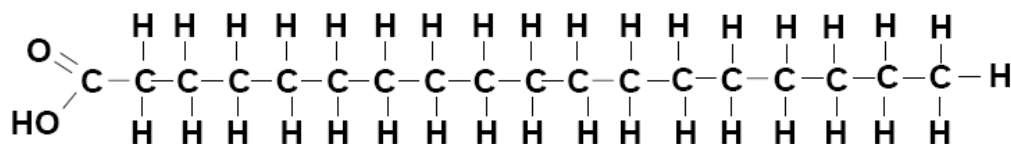
Notes on Lipids and Health

True lipids (triglycerides)

- composed of a **glycerol** molecule covalently bound to three **fatty acid** side chains
- **hydrophobic** molecules, meaning they are non-polar and don't mix with water
- a group of triglycerides is called a **fat**

Saturated fats

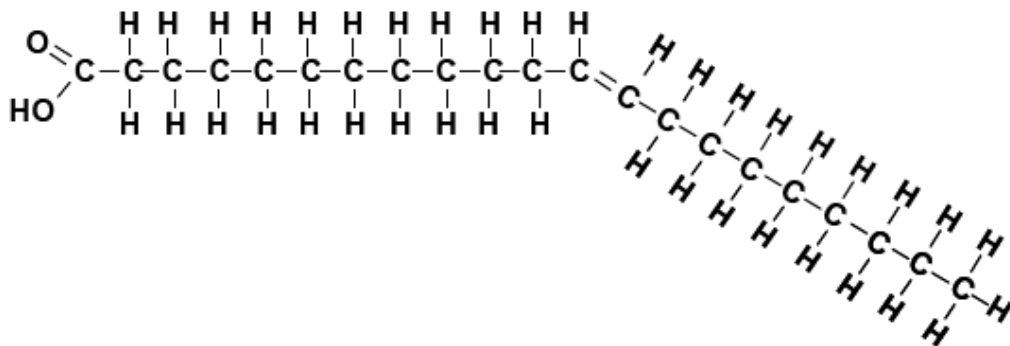
- solid at room temperature (think of fat on an uncooked steak)
- hydrocarbon chains in fatty acids have no carbon-carbon double covalent bonds
- maximum number of hydrogens are covalently bound to the carbons, thereby "saturating" them
- animal fats such as lard and butter are usually high in saturated fatty acids



Saturated
Fatty Acid

Unsaturated fats

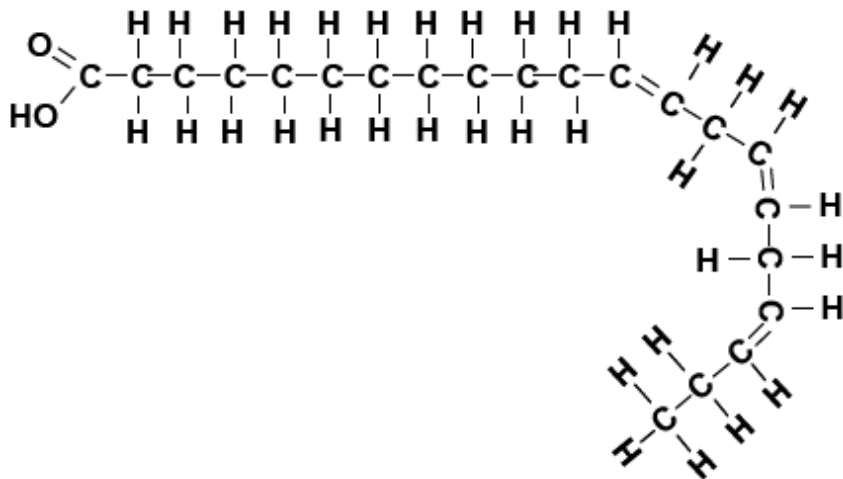
- liquid (oils) at room temperature
- hydrocarbon chains of the fatty acids have at least one (**monounsaturated**) or more (**polyunsaturated**) carbon-carbon double covalent bonds
- double bonds cause bends in the molecules and also leave them "unsaturated" with hydrogens
- unsaturated fats are found in plant oils such as olive or canola oil



Monounsaturated
Fatty Acid

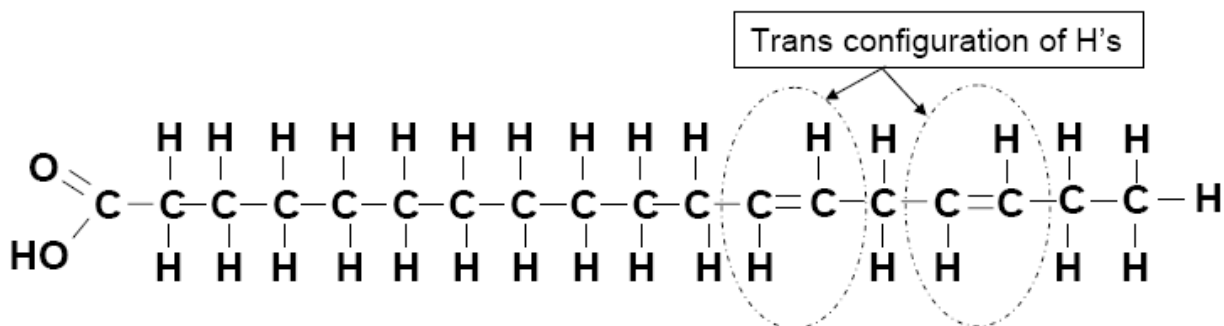
Dietary fatty acids

- fatty acids are a necessary component of a complete diet
- fatty acids are found in foods such as fatty meats, plant oils and dairy products
- certain polyunsaturated fatty acids (called **essential fatty acids**) cannot be synthesized by the human body and must come from the diet
- one such essential fatty acid is linoleic acid which can be found in foods such as sunflower oil and almonds
- both monounsaturated and polyunsaturated fatty acids can be found in plant oils

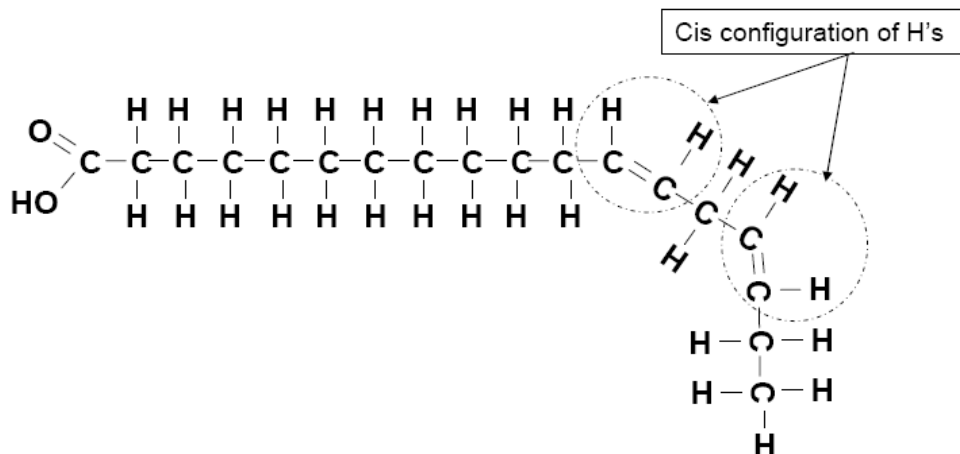


Trans fats

- are triglycerides that contain **trans fatty acids**
- Trans means “across” so...
- **a trans fatty acid** is an unsaturated one in which the hydrogens attached to adjacent carbons in a carbon-carbon double covalent bond are on opposite sides of the molecule
- produced by the process of adding hydrogens to unsaturated vegetable oils
- hydrogenation decreases the number of carbon-carbon double covalent bonds in the molecules and creates what are known as “**hydrogenated**” or “**partially hydrogenated**” vegetable oils
- trans configuration gives the fatty acids chemical properties more similar to saturated fatty acids (such as lack of bends in the molecules) and can also lead to some accumulation of “bad” types of cholesterol when consumed
- trans fats are found in any hydrogenated oils, so margarines and shortening made from vegetable oils are major sources
- since they are made from plant oils, these were once touted as being much healthier than saturated animal fats



- in **cis fatty acids**, the hydrogens attached to adjacent carbons in a carbon-carbon double covalent bond are on the same side of the molecule.
- Almost all naturally occurring unsaturated fatty acids are cis isomers



So, the doctor says your cholesterol is too high... When you were finally called back to a room, your doctor said that a standard analysis of your blood showed that your **total cholesterol** level was 250mg/dL (a dL=deciliter, or 1/10 of a liter, 100mL). He/she explained that a total cholesterol level of 240mg/dL or above is considered high and is a risk factor for coronary artery disease (CAD).

In continuing conversations with your physician, you learned that as a general rule cholesterol is not always “bad.” In fact, cholesterol is a necessary component of cell membranes and is a vital part of normal metabolic processes, including formation of other steroids. In addition to looking at total cholesterol concentration in your blood, your doctor emphasized that it is important to take notice of **high density lipoprotein (HDL)** cholesterol and **low density lipoprotein (LDL)** cholesterol, which make up major fractions of the total cholesterol and may be more accurate indicators of CAD risk.

Your LDL fraction was found to be 195mg/dL which is considered very high.

After seeing your very high LDL number, your physician went on to say that the role of LDLs is to carry cholesterol around in the bloodstream and deposit it where it is needed. Unfortunately, if the level of LDLs becomes too high they can also deposit the cholesterol in arteries, forming “plaques” and clogging the arteries. On the other hand, HDLs are responsible for carrying excess cholesterol away from the arteries to the liver where it can be metabolized or “reprocessed” for other purposes. So, with this in mind, cholesterol bound in LDLs is often called “bad cholesterol” and cholesterol bound in HDLs is called “good cholesterol”. In order to avoid CAD, the average person should attempt to raise the level of HDLs in their blood and lower the level of LDLs, although both are needed at some level in the blood.

At this point, your doctor strongly urged you to exercise regularly and watch your diet because consumption of fats can have a profound effect on cholesterol levels in the body. However, it turns out that it is probably the *types of fat, not the total amount* of fat that you eat that may determine incidence of CAD. In fact, a 2001 study by Frank Hu and colleagues at the Harvard School of Public Health showed that different parts of the world with similar total fat intake had very different amounts of death from CAD. Individuals in countries where the fats eaten were mainly in the form of **saturated** fats and **trans** fats had much higher incidences of death from CAD than individuals in countries where the fats were mainly consumed in the form of **polyunsaturated** fats containing **omega-3 fatty acids**. In general, the study showed that consumption of saturated fats and trans fats tended to increase LDL cholesterol while consumption of polyunsaturated fats tended to both decrease LDL cholesterol and increase HDL cholesterol.

Useful Links:

More explanation about trans fats from the FDA

<http://www.fda.gov/Food/LabelingNutrition/ConsumerInformation/ucm109832.htm#unhide>

Understanding cholesterol numbers website

<http://www.webmd.com/cholesterol-management/guide/understanding-numbers>

Government information about reading nutrition labels

<http://www.fda.gov/Food/LabelingNutrition/ConsumerInformation/ucm078889.htm>

Read the Fatty Acids, Nutrition and Health reading and Chapter 3 in the text book and then answer the following questions before class.

1. A trans fatty acid is one
 - a. that has no carbon-carbon double bonds directly adjacent to each other.
 - b. that is a major component of phospholipids in cell membranes.
 - c. in which the hydrogens attached to adjacent carbons in a carbon-carbon double covalent bond are on opposite sides of the molecule.
 - d. in which the hydrogens attached to adjacent carbons in a carbon-carbon double covalent bond are on the same side of the molecule.
 - e. that is saturated with hydrogens.

2. Types of polyunsaturated fatty acids that are necessary in the human diet because they cannot be synthesized by the body are called _____ fatty acids.
 - a. essential
 - b. important
 - c. trans
 - d. omega-3
 - e. hydrophobic

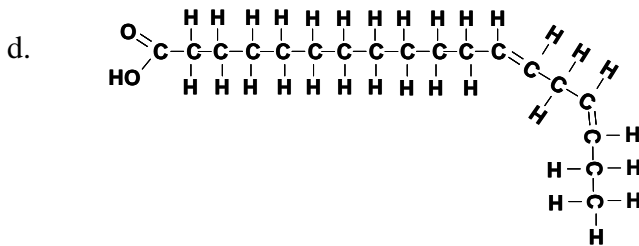
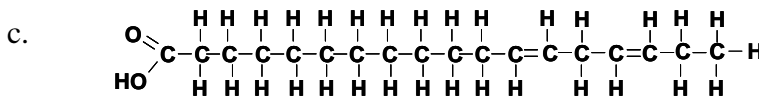
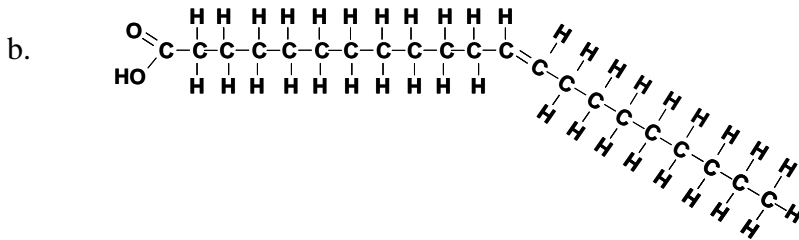
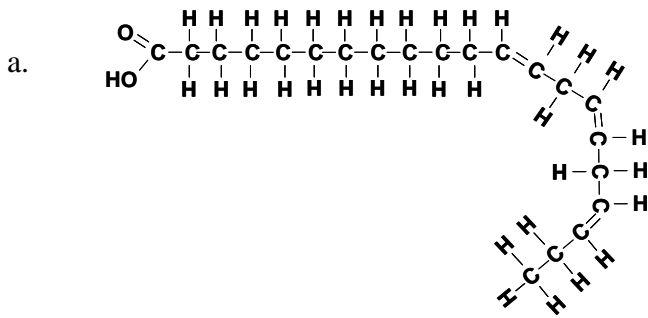
3. Generations of Americans were introduced to trans fats in their diet in the form of _____ which was hailed as a healthy alternative to the saturated fats found in butter and lard.
 - a. Coconut oil
 - b. Olive oil
 - c. Margarine
 - d. Canola oil
 - e. Beef tallow

4. HDL stands for
 - a. Highly dense lipid.
 - b. Hydrogenated dark lipid.
 - c. High density lipid.
 - d. Hydrogenated dense lipoprotein.
 - e. High density lipoprotein.

5. A true lipid is composed of glycerol and three fatty acids. What type of reaction is used to link each of the fatty acids to a glycerol molecule?
 - a. Dehydration
 - b. Hydrolysis
 - c. Dehydrohalogenation
 - d. Hydrogenation
 - e. Hydroxylation

6. Which one of the following would be solid at room temperature?
 - a. Cis fatty acids
 - b. Corn oil
 - c. Peanut oil
 - d. Saturated fats such as lard (pig fat)
 - e. Unsaturated fats

7. Which one of the following diagrams represents a trans fatty acid?



8. Food companies can tag their products on the nutrition label as having 0g of trans fats if they have <0.5g of trans fat per serving. What could be found in the ingredients list that is probably a better indicator of the presence of trans fats in foods than the trans fat line on the nutrition label?

- Lard
- Hydrogenated oils
- Palm oil
- Olive oil
- Almonds

9. Consumption of which of the following is most likely to raise your HDL and also lower your LDL levels?

- Trans fats
- Saturated fats
- Lard
- Polyunsaturated fats
- Margarine