Real World Connections
Bonding
Meyers/Hannah

Directions: Use the passage below and your knowledge of Chemistry to answer questions 1-5.

How Fats Work

Between the food commercials you see on TV every day and the many nutrition bulletins and reports you hear about on the news every night, you get a huge amount of information about the fats that you eat. For example, you have probably heard of the following terms:

- Saturated fat
- Unsaturated fat
- Polyunsaturated fat
- Mono-unsaturated fat
- Fatty acids
- Essential fatty acids
- Trans fatty acids
- Omega-3 and omega-6 fatty acids
- Partially hydrogenated fat

Nutrition Facts
Serving Size 2/3 cup (52g)
Servings Per Container: 6

Amount Per Serving	
Calories 180	Calories from Fat 50
	% DailyValue*
Total Fat 6g	9%
Saturated Fat 1g	4%
Cholesterol 0mg	0%
Sodium 50mg	2%
Potassium 240mg	7%
Total Carbohydrate 25g	10%

Have you ever wondered what it all means, or why it matters? Why can't we just eat, drink and be merry? In this article, you'll find out exactly what these terms mean and how the various forms of fat you find in foods affect your body.

We see **pure fats** in three places at the grocery store:

- In the **vegetable oil** aisle you see oils created from different seeds and nuts. There is corn oil, safflower oil, peanut oil, canola oil, olive oil... All seeds and nuts contain some amount of oil, because oil is a very good way to store energy. By the way, the only difference between oil and fat is whether or not it is a solid at room temperature.
- In the **meat** aisle, you can look at different cuts of meat and see them outlined by a layer of white, solid fat created by the animal to store energy.
- In the **dairy** aisle you see butter and margarine -- fat made from cream or vegetable oils, respectively.

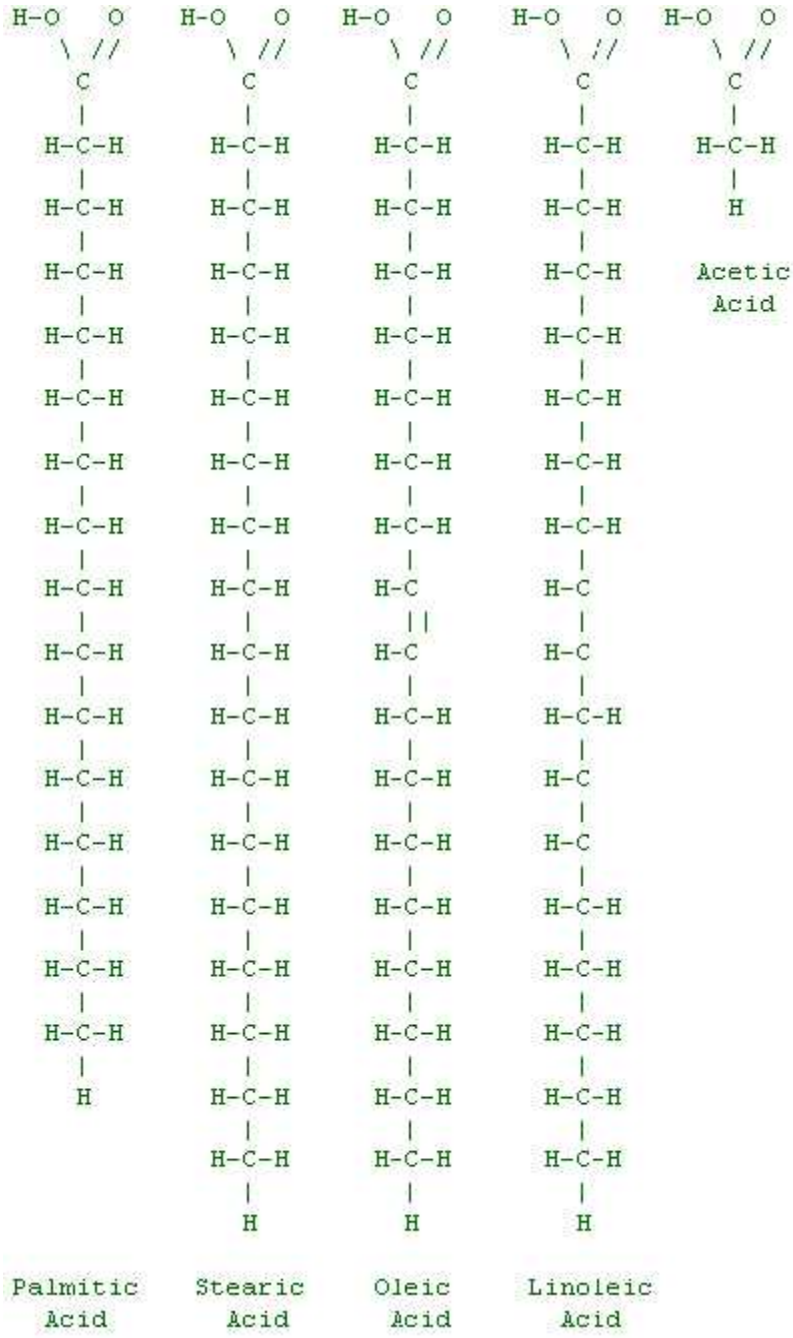
The rest of the grocery store is, of course, filled with fats and oils, although they are less obvious. Potato chips and french fries are cooked in oil, cookies and cakes contain fats and oils, and so on. This is how we come to eat the fat we need every day. And we do *need* fat - as you will learn below, there are certain fats that we must have to survive.

Corn Oil

With some grains and nuts it is very easy to see where the oil comes from. For example, if you squeeze a sesame seed or a sunflower seed between two sheets of paper, you can see the oil. Corn isn't quite that oily, but it does contain oil. A kernel of corn has an outer **husk** surrounding a white or yellow starchy substance. At the core of the starchy substance and toward the pointy end of the kernel is the **germ**. The germ contains a small amount of oil. If you cut a popcorn kernel in half, you can see the husk, starch and germ. If you cut out the tiny piece of germ and squeeze the germ on a piece of paper, you will see the oil!

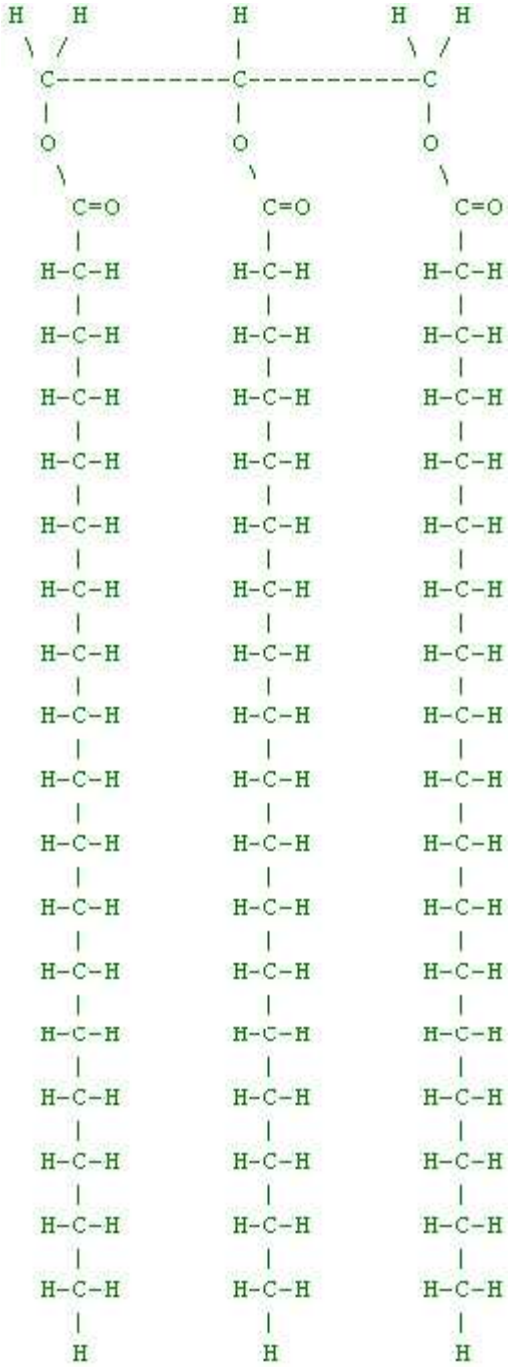
So what are these fats and oils really made of? Well, if you really want to understand fat you need to study a little bit of chemistry. To talk about fat, we need to start by talking about **fatty acids**.

A fatty acid is a long hydrocarbon chain capped by a **carboxyl group** (COOH). There are many common fatty acids that you hear about, four of which are shown below along with acetic acid for comparison:



The COOH cap is what makes these molecules acids. You are probably familiar with acetic acid because this is the acid found in vinegar. You can see that the fatty acids are like acetic acid, but they have much longer carbon chains.

To make a normal fat, you take three fatty acids and bond them together with glycerol to form a **triglyceride**, like this:



Since this particular triglyceride happens to contain three molecules of stearic acid, it is also known as **tristearin**. This diagram shows one fat molecule. When you eat fat, you are eating collections of molecules like these. The choice of the fatty acids in the fat controls many different things about the fat, including how it looks, whether it is a solid or a liquid at room temperature and how healthy it is for your body.

Saturated vs. Unsaturated

If you look at palmitic acid and stearic acid in the first figure, you can see that the carbon chains are completely and evenly filled with hydrogen atoms. In other words, the chains are **saturated** with hydrogen. Fats (triglycerides) that contain palmitic acid and stearic acid are therefore known as **saturated fats**. Fats made up of saturated fatty acids are solid at room temperature.

In the first figure, you can see that oleic acid is not saturated. Two of the carbons are connected by a double bond, and two of the hydrogens are missing. This fatty acid is **unsaturated**. Fats that have a lot of oleic acid in them are liquid at room temperature, and are therefore known to us as oils.

Oleic acid, because it contains one double bond, is also referred to as **mono-unsaturated**. Fatty acids that have multiple double bonds, like linoleic acid in the first figure, are called **polyunsaturated**. Polyunsaturated fats are also liquid at room temperature.

If you have a bottle of corn oil, what you have is a bottle of polyunsaturated oil with a high concentration of linoleic acid. Because it is polyunsaturated, it is liquid at room temperature. If you would like to solidify it and turn it into margarine, what you do is **hydrogenate** it. That is, you saturate it with hydrogen by breaking the carbon double bonds and attaching hydrogen. To do this, you heat the oil and add pressurized hydrogen gas and a nickel catalyst. In this way, you create "partially hydrogenated vegetable oil." PHVO is the main ingredient in things like vegetable shortening and margarine.

Fat and Health

Most of the nutrition science you hear about right now points to mono-unsaturated fats as the **good fats**. Olive oil and canola oil are both mono-unsaturated. Mono-unsaturated fats are thought to **lower cholesterol**.

In general, the fats to steer clear of are the saturated fats. Saturated fats are bad because they clog your arteries. Partially hydrogenated vegetable oils (which are artificially saturated fats) are now considered totally evil, both because of the saturation and a side-effect of hydrogenation called **trans fatty acids**.

Fatty acids that have double bonds come in two forms: **trans** and **cis**. "Trans" and "cis" refer to the direction of folding that occurs at the carbon double bonds in unsaturated fatty acids. Cis fatty acids are the normal, natural directions for the folds. A trans fatty acid is chemically identical to the cis form, but folds in an unnatural direction. The trans fatty acids are created by heat (as in deep frying) and by hydrogenation.

It turns out that in the body, the enzymes that deal with fat are unable to deal with the trans fatty acids (see How Cells Work for details on enzymes). Therefore, the enzymes get tied up trying to work on the trans fatty acids, and this can lead to problems with the processing of essential fatty acids.

Clogged Arteries

The heart is an amazing organ. It beats thousands of times each day, every day, for your entire life. In the process, it pumps about five million gallons of blood through your body!

The heart is a muscle, and it needs a supply of oxygen-rich blood to survive. Even though the heart has all of that blood flowing through it while it is pumping, it does not use that blood for its oxygen needs. Instead, there is a set of arteries and veins out on the surface of the heart muscle that feed it. If one of these outer arteries gets blocked, it causes a heart attack. A blockage like this is normally caused by fatty deposits that build up in the heart's arteries over the course of many years. Everything you hear about fat in the diet, cholesterol, coronary artery disease and "clogged arteries" is focused on this problem -- blocked heart arteries and the heart attacks they cause are a leading killer in the United States.

Essential Fatty Acids

The most common fatty acids are found in animal fats and include:

- Palmitic acid
- Stearic acid
- Oleic acid

Your body is able to create these fats whenever it has a caloric surplus. It can create them from straight sugar if there are enough sugar calories coming in.

It turns out that there is another class of fatty acids called **essential fatty acids** that your body cannot manufacture. These fatty acids include:

- Linoleic acid (LA) (omega-6)
- Arachidonic acid (AA) (omega-6)
- Gamma linolenic acid (GLA) (omega-6)
- Dihomogamma linolenic acid (DGLA) (omega-6)
- Alpha linolenic acid (LNA) (omega-3)
- Eicosapentaenoic acid (EPA) (omega-3)
- Docosahexaenoic acid (DHA) (omega-3)

Because your body cannot manufacture them, they must come in from the food you eat.

Essential fatty acids fall into two groups: omega-3 and omega-6. The 3 and 6 refer to the first carbon double bond position on the fatty acid chain. All essential fatty acids are polyunsaturated, so the 3 and the 6 mean that the first double bond is either 3 or 6 carbons in from the end.

Omega-6 fatty acids are everywhere: corn oil, sunflower oil and soybean oil all contain them. Omega-3 fatty acids are harder to find. Things like flax seeds, pumpkin seeds and walnuts are high in omega-3 fatty acids, as are salmon, trout and tuna. Current thinking is that these two fats need to be balanced in the diet at a ratio like 1-to-1 or 2-to-1, rather than the normal 20-to-1 ratio seen in most Western diets. About the only way to do that is to supplement your diet with omega-3 vegetable oils or to start eating fish in a big way (meaning two or three times a week).

Summarizing all of this information, the current scientific thinking on fat consumption goes something like this:

- Limit your fat intake to about **30 percent** of the total calories you consume. Do not try to cut fat intake altogether, because you do need the essential fatty acids. A gram of fat has nine calories, meaning that if you consume 2,000 calories in a day your total fat intake should hover around (2000 * 30 percent / 9 calories/gram) 67 grams of fat.
- When consuming fat, try to focus on **mono-unsaturated fats** like olive oil and canola oil, or on essential fatty acids.
- When consuming essential fatty acids, try to balance your intake of **omega-6 and omega-3** fatty acids. Do that by consuming tuna/salmon/trout or omega-3 oils like flax seed oil.