

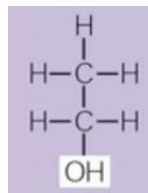
Lipids - 1

Many of our common substances are **lipids**, which include fats and oils (triglycerides), phospholipids, steroids (or sterols), eicosanoids, lipoproteins, waxes and terpenes. Alcohols are often discussed with lipids because they are lipid-soluble, but alcohols, chemically, are a different class of compounds. (Issues of alcohol and health are discussed in Highlight 7 of your textbook.) Lipids are grouped together because they are (mostly) hydrophobic, nonpolar and not soluble in water. In this section of our nutrition study we will focus on the chemical structure of lipids, what lipids do in our body and lipids in the diet, just as we will do with our other nutrients.

Lipid Structure

- Lipids, like carbohydrates, are formed from hydrocarbon backbones.
 - Lipids contain:
 - carbon
 - hydrogen
 - oxygen
 - Most lipids have a large proportion of C-H bonds with a very low proportion of oxygen so lipids are mostly **hydrocarbon**
 - Lipids are **energy rich** since the C-H bond is high in energy.
- | | |
|--------------|----------|
| lipids | 9 cal/gm |
| carbohydrate | 4 cal/gm |
| protein | 4 cal/gm |
| alcohol | 7 cal/gm |

Alcohol structure:



Lipid Functions

- Fats are important fuel reserve molecules. Fats are energy rich so they provide concentrated energy, especially for muscle activity including the heart and respiratory system (breathing). Humans store fat reserves in **adipose** tissue. Adipose cells have a remarkable ability to swell and shrink depending on the amount of fat reserves they contain.
- Phospholipids are the primary structural molecules of cell membranes.
- Fats insulate from cold and provide padding for internal organs.
- Many hormones (regulatory chemicals) are steroids.
- Fats in the diet carry essential fat soluble vitamins: A, D, E and K
- Fats in the diet have satiety value – they stay in stomach longer so we feel fuller longer.
- Fats provide protective coatings on the body surfaces to help prevent dehydration.

What are the major categories of lipids found in humans?

- Triglycerides commonly called fats/oils
- Phospholipids
- Sterols
- Lipoproteins (composite of lipid and protein)
- Fat-soluble vitamins

Let's look more closely at the structure and properties of the common lipids (or more than you might have thought you wanted to know about fats and oils):

Triglycerides: The Fats and Oils (95% of the lipids in our diet)

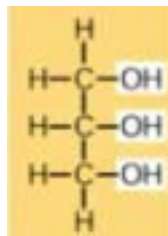
First, the terms fats and oils are terms of convention

Fats are "hard" or solid at room temperature

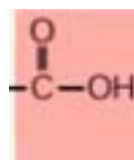
Oils are liquids at room temperature

All triglycerides have a common structure.

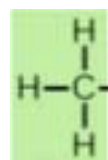
- One molecule of the alcohol, **glycerol**



- Attached to the glycerol (by dehydration synthesis or **condensation**, a reaction that removes a water molecule from the reacting substances) are **3 fatty acids**.
- **Fatty acids** are chains of hydrocarbons with the carboxyl (acid) functional group (COOH) at one end of the chain and a methyl group (CH₃) at the opposite end.



Carboxyl

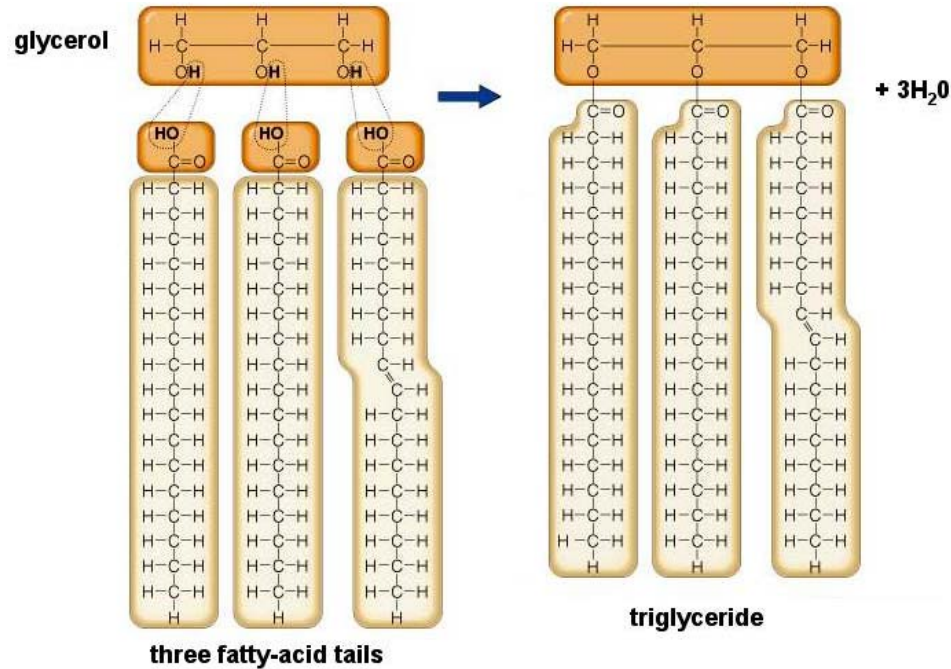


Methyl

- The fatty acid hydrocarbon tails are strictly non-polar, so that triglycerides are **hydrophobic** molecules.
- The fatty acids determine the characteristics or properties of the fat.

Lipids - 3

The three condensation reactions that form the triglyceride occur between the –OHs of glycerol and the –OHs of the fatty acids' carboxyl group. This bond is called an ester bond (something that's important in chemistry, but not so important for this class).



- Sometimes you will see mono or diglycerides. They are usually derivatives of partially degraded triglycerides, with just one or two fatty acids attached to the alcohol molecule.

Since it is the fatty acids that determine the properties of a fat, it's most important to look at ways that fatty acids are different.

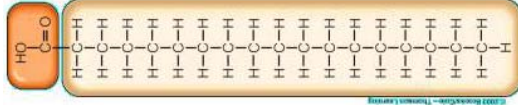
Fatty Acid Differences

1. Length of the Carbon Chain of the Fatty Acids

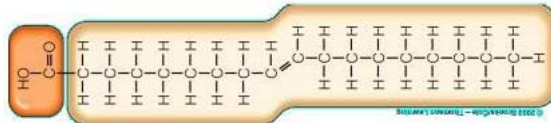
- Fatty acids have an even number of carbons from 4 – 26 carbon atoms in their hydrocarbon chain. Most are 14 – 18 carbons in length.
- Short chains are more soluble.
- Short chains are more easily broken down.
- Short chains are less dense.
- Short chains oxidize more easily (process by which fats become "rancid").
- Butyric acid (in butter) is the shortest fatty acid (4 C)

2. Saturation of the Fatty acid

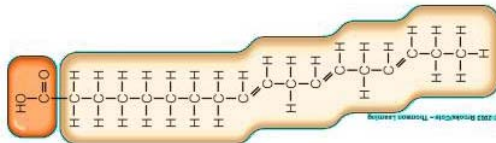
- Each carbon within the chain has a maximum of 2 places for bonds with hydrogen. (Remember carbon makes four bonds, two of which are to the adjacent carbon atoms on the chain).
- If each carbon has 2 hydrogen atoms attached to it, the fatty acid is **saturated**.



- If two carbon atoms in the fatty acid chain are **double bonded** to each other, so that there is less hydrogen in the fatty acid, it is **monounsaturated**.



- If more than 2 carbon atoms are unsaturated, the fatty acid is **polyunsaturated**.



- Most plant fats tend to be unsaturated, but fats from tropical plants tend to be very saturated
- Fish oils tend to be unsaturated (from cold water and salt water fish). Other animal fats tend to be saturated

Fatty Acid Composition of Some Common Triglycerides

Saturated fats
 Monounsaturated fats
 Polyunsaturated fats, w3 Linolenic acid, w6 Linoleic acid

- Animal fats and the tropical oils of coconut and palm are mostly saturated.

Coconut oil				w6
Butter				w6 w3
Beef tallow				w6 w3
Palm oil				w6
Lard				w6 w3

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

Olive oil				w6 w3
Canola oil				w6 w3
Peanut oil				w6

- Many vegetable oils are rich in polyunsaturated fatty acids.

Safflower oil				w6 w3
Sunflower oil				w6
Corn oil				w6 w3
Soybean oil				w6 w3
Cottonseed oil				w6

How do we deal with spoilage (oxidation) of fats?

Keeping fats from spoiling is important to the food industry for health and product shelf life purposes. There are a number of ways that fats can be protected from oxidation and spoilage.

- **Antioxidants**

Substances that prevent oxidation

BHT butylated hydroxytolulene

BHA butylated hydroxyanisole

Propyl gallate

Vitamin C and Vitamin E are also antioxidants)

- **Hydrogenation**

Hydrogenation is a chemical process that adds hydrogen to fatty acid chain.

- Vegetable oils are hydrogenated, especially in shortenings and in margarine, to make them solid.
- Hydrogenation may form **trans-fatty acids** that may not be used effectively by the body. Trans fatty acids have effects similar to saturated fatty acids on the body, and intake should be restricted. In the future, food labels will have to identify trans-fatty acid content. Now, the only clue is the statement "partially hydrogenated" on the ingredients list. Many snack foods are made with partially hydrogenated oils, as are almost all margarines.
- Hydrogenation also raises the temperature at which an oil will "smoke". In addition to the hazards of air pollution, the temperature at which an oil smokes also affects structure and may produce harmful by-products. These accumulate when fats are re-used in cooking. (Generally, more refined and less polyunsaturated oils are better for cooking.
- Hydrogenation to make fats firmer is not always necessary. A saturated hard fat could be mixed with unsaturated fat to obtain the desired texture. However this process wouldn't prevent oxidation.

- **Refrigeration**

- Cold temperatures retard oxidation.
- However cold temperatures may cause **crystallization** of fat molecules, which affects the texture of foods prepared with the fats.

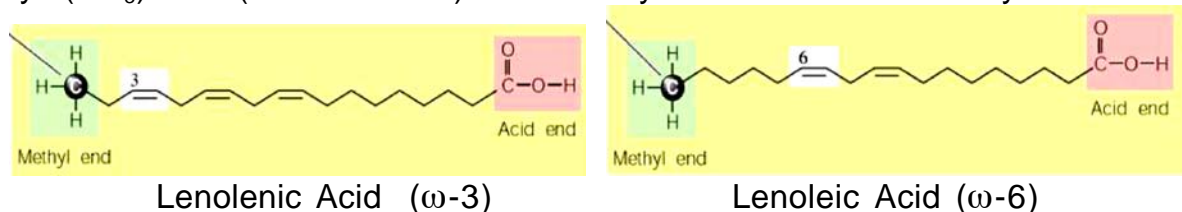
Are There Essential Fats?

- There are about 40 different fatty acids (some not common), of which we have two essential fatty acids, so we need include fats that contain these fatty acids.
- We are capable of converting the **majority** of the fatty acids that we eat in our diets to the specific fatty acids needed in the body.
- Some fatty acid interconversions require vitamin B₆
- If infants are fed a chronic low fat milk diet, skin lesions, called eczematous dermatitis, may result. (Note: The remedy is easy; just increase the fat content of the milk. Children under the age of two should probably drink whole milk.) It's also important that formula given to infants has the essential fatty acids.

The Essential Fatty Acids

Two groups of polyunsaturated fatty acids are essential: The omega-3 (ω -3) and omega-6 (ω -6) fatty acids. At least 3% of the fatty acids we consume should be the essential fatty acids, and ideally, in about equal proportion. We tend to get more than sufficient omega-6 fatty acids, but not omega-3 fatty acids.

Omega (ω) refers to the position of the first double bond of the carbon chain from the methyl (CH₃) end (non-acid end) of the fatty acid. It's a chemistry notation.



Linolenic Acid (ω -3)

Linoleic Acid (ω -6)

What are some of the omega (ω) fatty acids?

- Linoleic ω -6 with 18 carbons and 2 double bonds
- Arachidonic ω -6 with 20 carbons and 4 double bonds
- Linolenic ω -3 with 18 carbons and 3 double bonds
- Eicosapentaenoic (EPA) ω -3 with 20 carbons and 5 double bonds
- Docosahexaenoic (DHA) ω -3 with 22 carbons and 6 double bonds

Linoleic acid (an omega-6) and Linolenic acid (an omega-3) are not converted or manufactured from other fatty acids. We also can't manufacture the longer chain ω -6 and ω -3 fatty acids (the ones we actually use) unless the body has sufficient linoleic and linolenic acid on hand. Even then, we poorly convert the shorter ones into the longer. It's best to have reserves of the specific fatty acids needed.

Where do we find ω -6 and ω -3 fatty acids?

- Linoleic and arachidonic acids are fairly common in plant oils.
- Eicosapentaenoic acid and Docosahexaenoic acid are fairly common in cold water fatty fish
- Linolenic acid is found in some seed oils (flax, linseed, walnut, etc.)

What do the ω -6 and ω -3 fatty acids do?

We can state more easily what happens when we don't have enough of these fatty acids.

- In general, the lack of polyunsaturated fatty acids can result in growth retardation, skin, kidney and liver problems, and reproductive problems.
- Deficiencies of omega-6 fatty acids can cause skin lesions, since the omega-6 fatty acids are essential structural molecules.
- Deficiencies of omega-3 fatty acids can cause visual and nerve problems.
- The 20-carbon omega fatty acids are used in the manufacture of **eicosanoids**, which are a group of modified fatty acids that are important hormone-like chemical messengers. They include prostaglandins, thromboxanes and leukotrienes. Eicosanoids are important regulating body functions such as blood pressure, blood-clotting and immune system responses. Eicosanoids often have antagonistic responses. For example:
 - An ω -6 eicosanoid causes blood clotting and vessel constriction. Its counterpart ω -3 eicosanoid causes blood clotting, but not constriction
 - An ω -6 eicosanoid increases the rate of serum cholesterol breakdown. Its counterpart ω -3 is not as effective; it reduces cholesterol carriers, but doesn't affect breakdown of cholesterol

Eicosanoid Complications and Fatty Acids

Any eicosanoid can be made from either the omega-3 or the omega-6 fatty acid, **but** the eicosanoid works best when it is made from the desired omega fatty acid.

This problem is aggravated because dietary omega fatty acids (linoleic and linolenic mostly) are converted by the same chain-lengthening enzymes to the specific omega fatty acids used in the cells and tissues of the body. If too much of one omega fatty acid is ingested, it can interfere with the conversion of the other into the needed longer-chain fatty acids.

Since any ω -6 and ω -3 fatty acids of the right carbon length can and will be used in the manufacture of eicosanoids, we need to ingest a good mix of ω -6 and ω -3 fatty acids from whole foods. Taking supplements has had mixed results in studies, and in any case, might overwhelm the enzyme converters.

Our diets typically are high in omega-6 fatty acids but low in omega-three fatty acids. Increasing our intake of omega-3 fatty acids may help to:

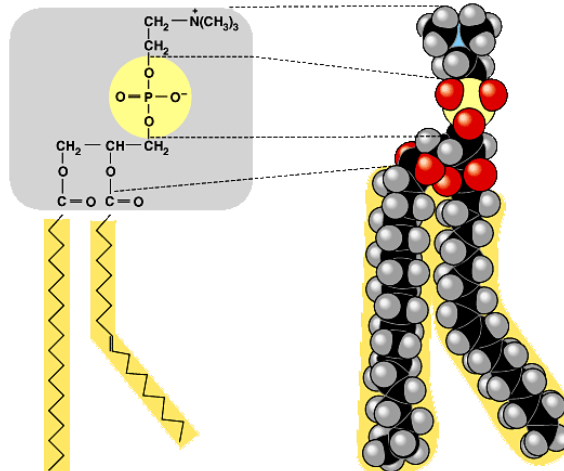
- Lower serum cholesterol and triglyceride levels.
- Raise HDL levels
- Reduce arteriosclerosis
- Lower cancer risks
- Reduce inflammatory responses, including arthritis pain

Although we have spent much time on triglycerides, and especially features of fatty acids, there are also other lipids of interest.

Phospholipids

Phospholipids are modified triglycerides that are the major component of **all** membranes of cells. They are also useful emulsifiers, particularly in food products.

Phospholipids are composed of a **glycerol** molecule with two fatty acids attached by ester bonds and a highly polar phosphate-containing compound attached to the third carbon. The phosphate portion forms the head of the molecule and the two fatty acids form tails.



Cell membranes are structured from a **phospholipid bilayer** -- with the **hydrophilic** heads pointed to the external and the internal environments, and the **hydrophobic** fatty acid tails pointing towards each other.

The most common phospholipid is **lecithin**, in which the molecule, **choline**, is attached to the phosphate portion. (Choline is sometimes considered a vitamin {B complex}. Choline is also a component of the neurotransmitter chemical, acetylcholine.)

Are phospholipids essential in the diet?

- Phospholipids **are not essential** nutrients. They can be manufactured by the body (liver) from virtually any fats eaten.
- All non-processed food has phospholipid as a part of the cell structure.
- We digest ingested phospholipid to: glycerol, fatty acids and phosphate compounds

Are phospholipid supplements, especially lecithin, useful?

When ingested as a supplement, phospholipids are digested just like any other lipid, yielding 9 calories per gram. Little, if any of the phospholipid will enter the blood. However, lecithin is often advertised as a needed supplement for a variety of purposes.

Lecithin controversies

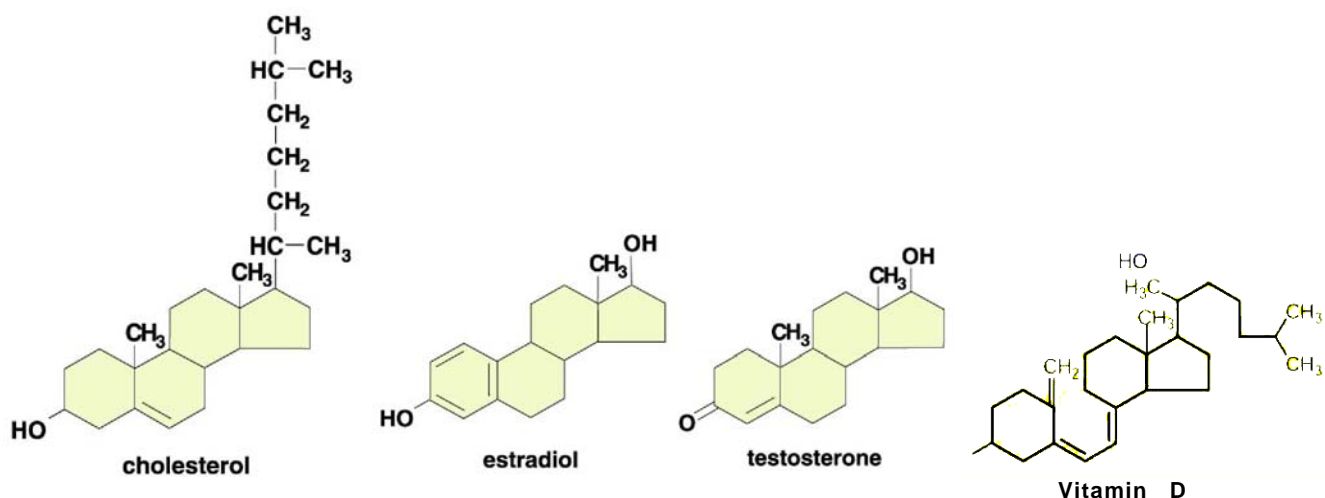
Some claim that lecithin lowers blood cholesterol levels. There is no evidence to support this. Lecithin's fatty acids are unsaturated, so it has just the same value in our diet as any other unsaturated lipid.

Some claim that lecithin improves memory. Again there is no evidence to support this. There are some memory disorders that respond to **drug levels** of choline. Such high levels in circulation increase the brain's absorption, increasing the concentration of acetylcholine. Any drug needs to be administered under medical supervision. Just eating foods rich in lecithin, or taking supplements is no assurance of any benefit.

Sterols

Sterols or Steroids are used for a variety of purposes in the body.

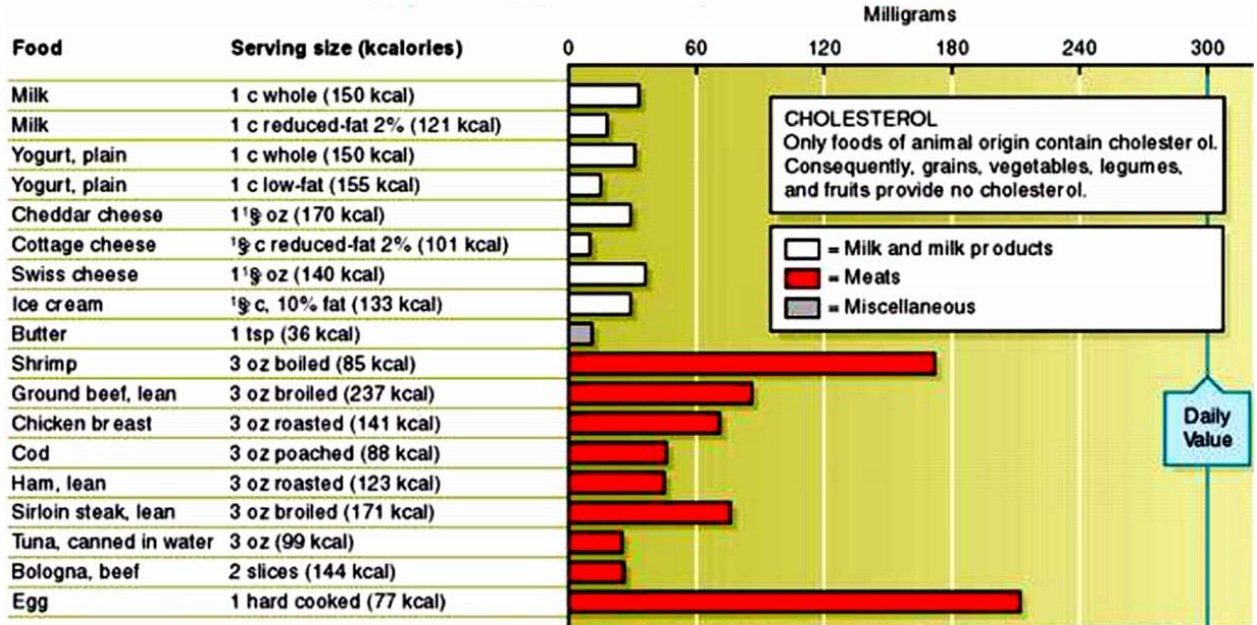
- Vitamins A & D are steroids.
- Several hormones, including the sex hormones, some growth hormones, and hormones of the adrenal cortex are steroids.



- **Cholesterol**, the most abundant steroid, is a structural component of cell membranes, most abundant in nerve and brain tissue.
 - Cholesterol is the precursor for vitamin D and the steroid hormones.
 - Cholesterol is a component of bile salts.
 - All cholesterol needed is made in the liver from digested fatty acids.
 - Dietary cholesterol is not necessarily related to blood levels of cholesterol. The liver synthesizes 1-3 grams/day vs. 300mg -1 gram ingested.
 - Cholesterol carried by LDL (low density lipoproteins) in the circulatory system is a definite risk factor for cardiovascular disease, especially atherosclerosis, a subject to be discussed later. However it's important to minimize the amount of cholesterol in circulation, and diet has an important role in doing so.

- **Some correlations for blood cholesterol levels and health**
 - High saturated triglycerides in the diet are related to high levels of LDLs and blood cholesterol.
 - Monounsaturated fat intake is neutral with reference to blood cholesterol levels; however, cultures that have diets rich in monounsaturated fatty acids have low rates of cardiovascular disease. It may be more than the fat they choose, too.
 - High intake of polyunsaturated triglycerides may lower blood cholesterol. Omega-3 fatty acids seem to have the best effect on lowering cholesterol
 - High dietary cholesterol may increase serum (blood) cholesterol or not. It depends on whether liver synthesizes less to compensate for more cholesterol being absorbed. Most dietary cholesterol is digested into fatty acids for transport in chylomicrons to the liver. But it does provide a source of fatty acids.
 - Some soluble fibers attract cholesterol and can reduce digestion and absorption of cholesterol. Again, whether this lowers blood levels of cholesterol still depends of what the liver synthesizes from other fats in the diet.

Sources of cholesterol in diet



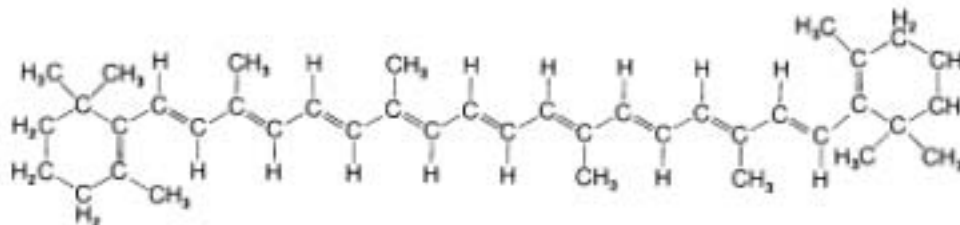
To compare:

- brains 1700 mg/ 3 oz
- kidney 680 mg/ 3 oz
- liver 370 mg/ 3 oz

There are no plant sources of cholesterol, although there are a few plant steroids, some of which are chemically similar to the estrogen hormones.

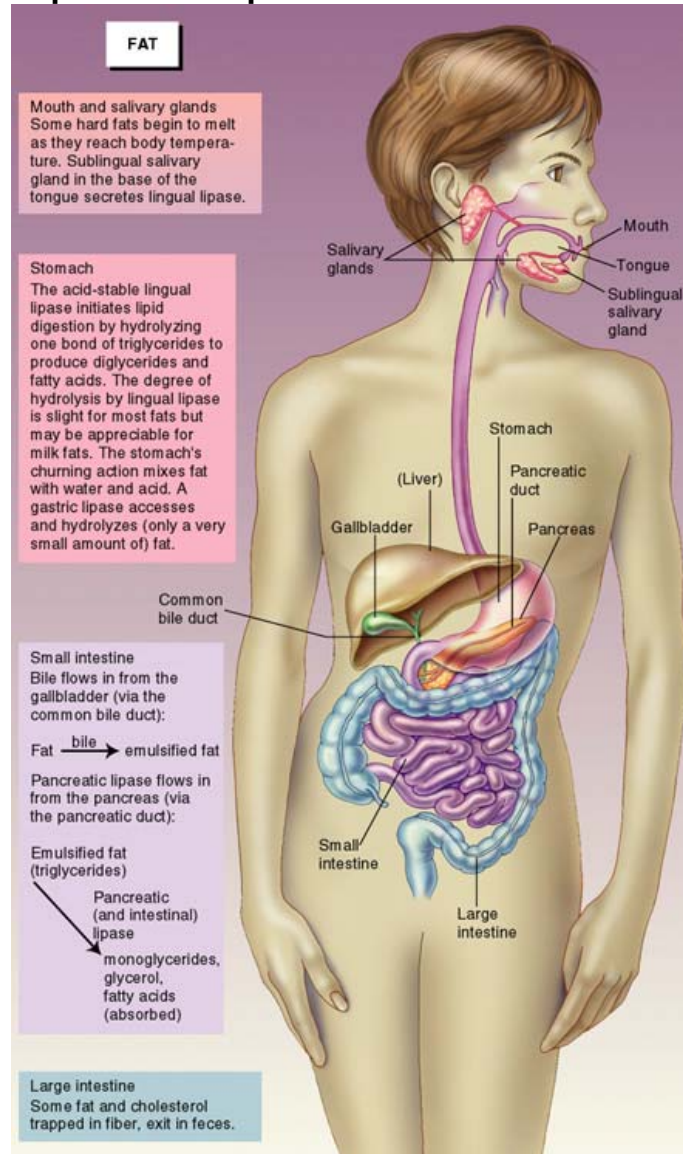
Terpenes

Although not really a part of the lipids we find in our body, terpenes are a group of lipid-related substances found in plants that includes the carotenoid pigments that are responsible for the orange, red and yellow colors of many plants. Vitamin A can be synthesized from carotenes. There are over 22,000 different terpenes in plants. Many of the aromatic oils found in herbs, flavorings and spices are terpenes. Lycopene and zeatin, two phytochemicals of interest as possible anti-cancer substances, are terpenes. Taxol, an extract from yew, is used to treat ovarian cancer, and digitalin is a cardiac medicine.



(β -carotene)

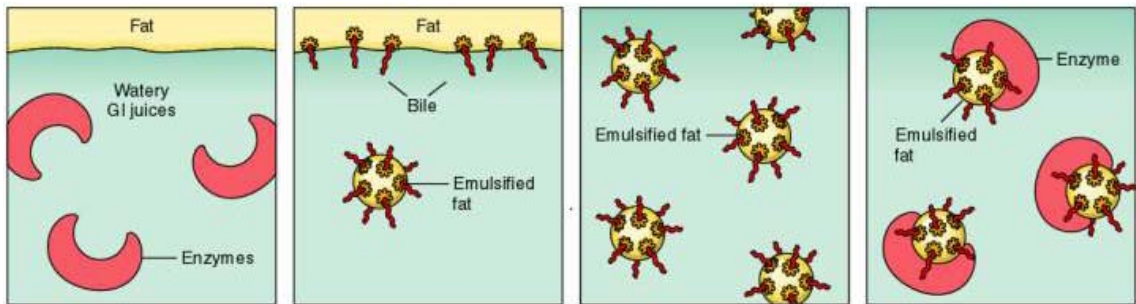
Digestion and Absorption of Lipids



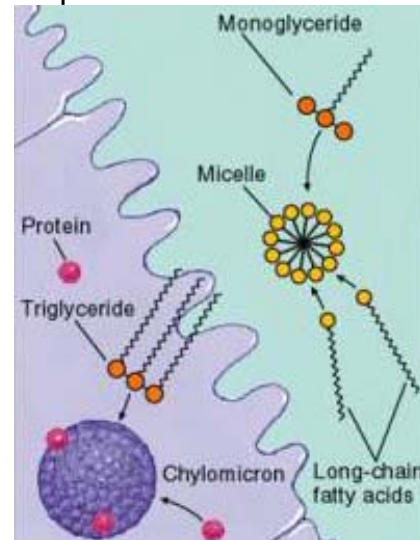
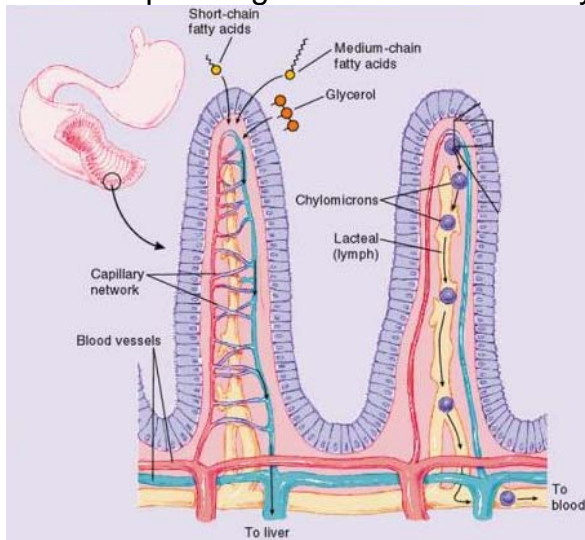
- A minimal amount of fat digestion occurs in the oral cavity. The temperature melts some of the shortest chain fats, and a salivary lipase initiates digestion of some of these.
- The salivary lipase is stable in the stomach and minimal digestion of triglycerides into diglycerides and fatty acids occurs. A gastric lipase also minimally digests lipids. Most lipids remain undigested in the stomach.
- Fats separate from rest of the food bolus in the stomach into fat globules that float in the chyme. Fats pass more slowly into the small intestine than other chyme materials.

Lipids - 14

- Fats are emulsified in small intestine by bile, produced in the liver, stored in the gall bladder and secreted through the common bile duct into the duodenum of the small intestine.



- Fats are enzymatically digested by pancreatic lipases to:
 - glycerol
 - fatty acids
 - monoglycerides (plus some diglycerides and even some triglycerides)
- Some fats and cholesterol are combined with fiber, transported to the colon and eliminated.
- The digested lipid molecules naturally form spherical complexes call micelles with their fatty acid tails toward the interior with the assistance of bile for migration into the cells of the villi.
- The micelles are processed in the intestinal microvilli into new triglycerides and packaged into **chylomicrons**, a type of **lipoprotein**, for export in lymph. Some small lipid fragments travel directly into capillaries.



- Once the lymph delivers the chylomicrons to the circulatory system, they are available to cells that may remove some triglycerides for use as the chylomicrons transit to the liver for reprocessing.
- After reprocessing in the liver, lipids are repackaged with a new protein layer for circulation, since the basic lipid-plasma incompatibility always exists.
- The resultant protein-surrounded lipid is a new lipoprotein that has a high proportion of fat to protein, and is known as a **low density lipoprotein**, or **LDL**. The kinds and proportions of lipoproteins in circulation are very important to health.

The Lipoproteins:

Chylomicrons

- Very low proportion of protein to lipid
- Carry digested lipids from intestine into lymph and ultimately through the circulatory system to the liver for processing and repackaging

Very Low-density lipoprotein (VLDL)

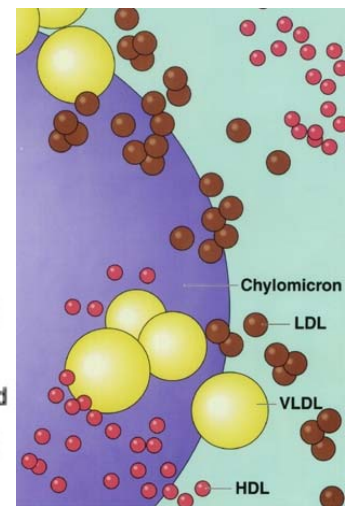
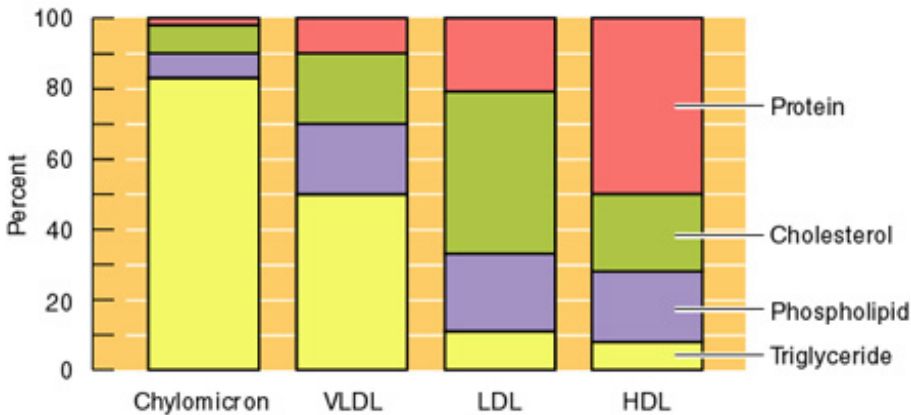
- Low proportion of protein to lipid
- Carry triglycerides, cholesterol and other lipids processed and synthesized in the liver to cells and tissues
- As VLDL circulate, they release their lipids, and also pick up cholesterol from the body forming low density lipoproteins

Low density lipoprotein (LDL)

- Continue in circulation making their contents available to cells, eventually returning to the liver for reprocessing. LDLs are proportionally high in cholesterol relative to other lipids.
- A high proportion of LDL is a risk factor in cardiovascular disease

High-density lipoprotein (HDL)

- High proportion of protein to lipid
- Carry cholesterol, glycerol and fatty acids released from tissues (especially adipose stores) back to the liver for processing, recycling or disposal



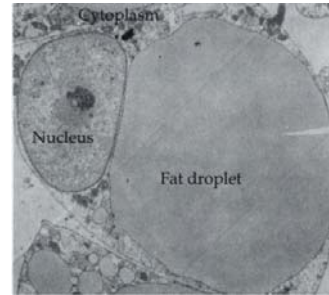
Lipoprotein Sizes

Storing Fat

- Fat is stored in special fat cells, **adipose cells**, that expand to hold fat. These cells have an enzyme on their surface which attracts fat molecules.
- The number and distribution of fat cells has a genetic component.
- The number of fat cells is often established very early in childhood.
- There is evidence that the number of fat cells does not change, but the quantity of fat held does fluctuate.



Adipose Cells



SEM of Fat Cell

Using our Fat Reserves

- Much of our stored fat (adipose) is our needed energy reserve for when the body's glucose reserves are down.
- Adipose fats are broken down to fatty acids and glycerol in the adipose (fat) cell
- Fatty acids and glycerol are then circulated by HDLs to cells and tissues, and to the liver.
- Glycerol (one molecule per triglyceride) can be converted to pyruvate or glucose for fuel in cells
- Fatty acids taken up by cells and tissues and processed for use in aerobic cell respiration (discussed in a later section).
 - They work well in muscle tissue when adequate oxygen is available.
 - They are not available to the brain and nervous system cells.
- In the cells the fatty acids fragmented into:
 - Keto acids
 - Acetyl used in Krebs cycle to provide ATP
 - Ketone bodies (usually formed after several days of fasting)
 - Keto acids and Ketone bodies can get into the brain for use as fuel.
 - Ketone bodies and keto acids are very toxic (**ketosis**) and may cause:
 - Blood pH imbalance
 - Kidney damage
 - Dehydration (by kidney excretion to remove ketones)
 - Possible coma
 - It's important to have sufficient carbohydrates to mix with fats to prevent making ketones in excessive quantities.

Lipids in the Diet

Before we turn to the relationship of fat in our diet and cardiovascular disease, let's take a realistic look at the role of lipid in the diet and where we obtain fats in foods (back to the pyramid).

Recall that virtually **all** evidence says that:

- People in the U.S. consume too much fat.
Recommend 20 – 25 (30)% of our calories come from fat.
That's about 60-80 gms/day for most of us.
- People in the U.S. consume too much **saturated** fat for optimal health.
A maximum of 10% of our fat intake should be saturated and/or trans-fatty acids.
- Much of our fat intake is hidden in our dairy and meat choices, so we are unaware of our fat consumption.
- Fat has 9 cal/gm compared to 4 for carbohydrate and protein. High fat foods are always calorie dense.

Food Exchange systems are particularly useful for revealing fat content in one's diet, as long as we are aware that exchanges are a calculation of exchange equivalent portions, not serving sizes.

Some fat exchange portions that have 5 grams (45 calories) of fat

- 1 teaspoon butter, oil, salad dressing or cream
- 1 oz cheese (or less)
- 5 olives (small ones)
- 1/8 avocado (small one)
- 2 macadamia nuts
- 1 piece of thin-sliced bacon
- 1 cup of 2% milk
- 1 biscuit or muffin, or
- 5 snack crackers

Suggestions for Reducing our Fat Intake (Never Hurts to Repeat)

- Substitute non fat, or at least low fat products for high fat ingredients in diet. This is most easy to do with dairy foods. With the exception of cheese and ice cream*, the lower fat dairy products are wholesome and delicious. Low fat cheeses are definitely lacking in taste. *Low fat ice cream used in sundaes, malts, etc. is fine.
- Increase consumption of whole grains, fruits and vegetables. They are naturally low in fat.
- Decrease consumption of high fat animal products by eating more fish. Very lean poultry and very lean meats are acceptable, but the method of preparation is important. Too often we fry our meat products, or eat them with added fats. Broiled meats will have a bit less fat.
- Reduce the portion size of the meats and poultry consumed.

These changes will result in a more nutrient dense diet, simply because the total calories consumed may diminish, leaving more calories to choose from other foods. Of course if you substitute empty sugar foods, you haven't gained much. If weight control is an issue, it's still total calories that count.

Health Reminders Associate with Fat Intake

Cardiovascular Disease Risk

Diets high in saturated fat that result in high levels of LDLs and triglycerides in the blood are a major risk in cardiovascular disease. Cultures whose fat intake comes from monounsaturated fats and omega-3 fatty acids have lower risks of cardiovascular disease.

Obesity Risk

Fats are calorie dense so it is easier to over consume calories when one's diet is high in fat. Moreover, few high fat foods are nutrient dense (cheese and nuts excepted).

Cancer Risk

There is a correlation between diets high in animal fats (other than dairy fats) and some cancers in some studies, but not in others. The American Cancer Society recommends a diet low in fat, and low in saturated fat, for overall health.

Insufficient Fat Intake Risk

Consuming too little fat has serious health risks, too, particularly with reference to hormone synthesis. Younger women, especially, may take in so little fat that they stop menstruating because they can't synthesize essential hormones. A diet that has less than 15% fat can put one at risk for deficiencies. Children under the age of two should have plenty of fat for development of body tissues and organs.

The Fat Substitutes

For the past several decades there have been a variety of sugar substitutes. With the advent of aspartame, the use of non-caloric sugar substitutes jumped dramatically. It is not surprising, then, that manufacturers would seek substitutes for the high-calorie fats in our diets. Actually, so many of our "sweets" and snack foods are more than 50% fat that it has been suggested that we should call them "fats".

Although we like to think that a food that contains a fat substitute means we will consume fewer calories, and be healthier, eating fat-free foods may not be effective for those who consume too many calories for optimal health and just eat the same number of total calories in other foods. Many of our reduced fat foods, like many of our sugar-free foods have almost the same number of calories as their full-fat counterparts.

For some, however, consuming foods containing fat substitutes may be a way to enjoy foods they like while reducing the total amount of fat in their diets. We must always be cautious about using substitutes as a way to continue making food choices that do not promote health and fitness.

Some Fat Substitutes

Olestra is a synthetic fat, marketed under the trade name of Olean. It mimics the texture and properties of triglycerides, is fat soluble, but not digestible or absorbed into the body, so all olestra consumed passes through the digestive tract. Hence, it is considered to be calorie-free. On its way through the intestines, olestra attracts cholesterol, minimizing the digestion of cholesterol. It also attracts vitamins A, D, E and K, and carotenes, and inhibits their absorption. Olestra is required by the FDA be fortified with Vitamins A, D, E and K. For some, consumption of olestra-containing foods results in intestinal discomfort of cramps, gas and/or diarrhea. One might also mention that its slickness, shall one say, may promote passage through that terminal sphincter, too. (It's tactfully referred to as "anal leakage".)

Olestra is a sucrose polyester, composed of fatty acids attached to sucrose rather than to glycerol. Six to eight fatty acids are attached to the sucrose molecule so the lipase digestive enzymes can't function to hydrolyze the ester bonds. Olestra looks, feels and tastes like a vegetable oil.

Olestra is synthesized from cottonseed or soybean oil, heated in a base-catalyzed reaction with methanol to detach the fatty acids as methyl esters. The glycerol settles out and is drawn off, and the fatty acid methyl esters are distilled. Sucrose and another base catalyst are then added to the fatty acid methyl esters, with emulsifiers. Under high temperature, sucrose polyesters form and the methanol is removed. Further processing removes leftover fatty acid esters and emulsifiers. The processing is completed with bleaching and deodorizing.
(information about structure and processing of Olestra from C&E News 4/21/97.)

Simplese is a fat substitute approved in 1990 that mimics the texture of fat in the oral cavity. It is synthesized from egg and milk proteins heated and whipped into microscopic globules (50 billion/teaspoon) that simulate the smooth texture of fat in the mouth, for use in artificial frozen desserts and cheese spreads. Simplese is not heat stable, and cannot substitute for fats in frying or baking.

Salatrim is a modified fat containing a combination of short and longer-chained fatty acids that tolerates some heating, but not temperatures used in frying. It is partially digested, but has fewer calories/gram than fats.

Caprenin is a fat constructed of fatty acids we digest poorly, so its calorie content is reduced. It can be used in baked goods, but not fried foods.

In some cases, products containing large amounts of **soluble fiber** can be used in baking to achieve the same texture and moisture content of the baked product that added fat does. Fruit purees (rich in pectins) are examples of fat substitutes sometimes used.