NATURAL CHOICES
INFORMED DECISIONS

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FATS AND OILS

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In nutrition, the terms fats, fatty acids, oils and cholesterol are sometimes referred to as "lipids." Lipids are one of the three macronutrient categories of nutrition; the other two categories being proteins and carbohydrates.

The confusing thing about fats is that some are "essential," some are good (but not "essential") and some are bad for human health. In the minds of many dieters, all fats are assumed to be villains. However, we will later see why this assumption may be very dangerous to the dieter's health. In the diet of many individual Americans, one or more of the following problems relative to fats is of concern:

- There is a deficiency of "essential" fatty acids. This can be called a "nutrient deficiency."
- The percentage of total dietary calories that are from all fats (good and bad) is too high. This can be called a "nutrient imbalance."
- Most of the fats consumed are saturated or otherwise inferior (i.e., margarine, partially hydrogenated oils, or oils that have been commercially heated and are oxidized). This can be called a "nutrient excess."

Certain fats are an essential part of the human diet. The omega-3 and omega-6 fatty acids are considered "essential" because they serve very important functions in the human body and the human body needs to obtain these fats through the diet. Americans are most commonly deficient in omega-3 fatty acids.

As will be explained in greater depth later in this article, most Americans consume omega-6 fatty acids in quantities much greater than are ideal, relative to the amount of omega-3 fatty acids. The reason for this is that food-processing companies prefer to work with omega-6 fatty acids (versus omega-3) because omega-6 fatty acids are more stable and have a longer shelf life. Therefore, in most supermarkets we find the omega-6 fatty acids disturbingly over-represented (relative to omega-3) in oil products and most other processed foods.

Although not considered essential, the monounsaturated omega-9 fatty acids (found in olive oil) are very beneficial as well.

A lipid is a compound made up of carbon, hydrogen and oxygen that is not soluble in water. Lipids enter the body through the mouth, pass relatively unaffected through the stomach and are absorbed primarily in the small intestines. There they are emulsified by salts of the bile acids and are hydrolyzed to fatty acids and glycerol by various water-solubilizing enzymes (lipases). From the intestines, the hydrolyzed lipids enter the bloodstream and are transported to other organs, mainly the liver, for further metabolism. Ultimately the fatty acids may be degraded to carbon dioxide and water to furnish energy.

It is desirable to limit overall intake of fats to no more than 30 percent of total calories consumed; the ideal is around 20 percent.

There are three major dietary lipid categories:

1. Triglycerides
2. Phospholipids
3. Sterols (including cholesterol)

TRIGLYCERIDES

A majority of the fats in the human diet are of the triglyceride variety. A triglyceride is made up of a glycerol molecule and three fat molecules referred to as "fatty acids."

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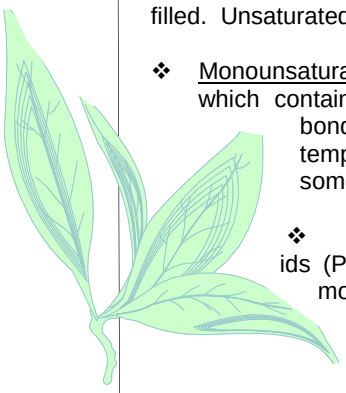
Fatty acids can be divided into two categories: saturated and unsaturated.

Saturated Fatty Acids

Saturated fatty acids are fatty acids containing the maximum number of hydrogen atoms. Saturated fatty acids fall into three categories with reference to the number of carbon atoms: short-chain, medium-chain and long-chain. Short-chain saturated fatty acids are found in butter (butyric acid), milk fat and coconut oil. Medium-chain saturated fatty acids (also called medium-chain triglycerides) are helpful for people with digestive or liver problems and for athletes (who appreciate the relatively quick conversion to energy in the body). Long-chain saturated fatty acids (including stearic acid) are found in animal products (stearic acid is found particularly in beef and pork), are solid at body temperature and have a tendency to make platelets in the blood clump together when consumed by humans. Inappropriate clumping of platelets can (along with other factors discussed later in this article) later lead to cardiovascular problems.

Unsaturated Fatty Acids

Unsaturated fatty acids are triglycerides in which one or more of the hydrogen "slots" are not filled. Unsaturated fatty acids include:



- Monounsaturated fatty acids (MUFAs), which contain one carbon=carbon double bond. They are liquid at room temperature, but tend to thicken somewhat in the refrigerator.

- Polyunsaturated fatty acids (PUFAs), which contain two or more carbons=carbon double bonds. They are liquid at room temperature and remain liquid in the refrigerator. (Examples of PUFAs are the omega-3 and omega-6 fatty acids discussed in the Essential Fatty Acids section.)

Essential Fatty Acids

Omega-3 and Omega-6 series of PUFAs are considered "essential" because they are necessary for human health; we cannot synthesize them, and therefore we need to take them into the body through our diet.

As will be explained later in this section, we can obtain essential fatty acids (or "EFAs") by consuming cold-water fish (such as salmon), oils derived from such fish, flax seed oil, evening primrose oil and borage oil. Essential fatty acids ("EFAs") play a key role in many functions in the body, including:

- the production of energy in the body by working with other nutrients (such as B-complex vitamins and various minerals) to increase the rate of metabolism
- as a component of nerve cells and cell membranes
- conversion to prostaglandins as a product of fatty acid metabolism.

Prostaglandins are hormone-like substances derived from 20-carbon-chain fatty acids. Prostaglandin 1 (PG1) and 3 (PG3) series are good because they:

- regulate platelets and other blood clotting factors in ways that are not yet fully understood
- improve blood flow and regulate blood pressure
- regulate inflammation, swelling and the allergic response
- regulate nerve transmission
- regulate steroid production and hormone synthesis

Prostaglandin 2 (PG2) series are bad (when in excess) because they cause platelets to stick together, which can cause hardening of the arteries, strokes and heart disease.

Omega-3 fatty acids lead to the 3 series of prostaglandins (PG3). The omega-3 prostaglandin pathway can begin with alpha-linolenic acid, which eventually can be converted through several enzymatic steps to eicosapentaenoic acid (or EPA) if several nutritional conditions are met:

- sufficient vitamins B6, B3 (niacin), C; magnesium and zinc are present
- not too much trans fatty acids, saturated fats, or alcohol are present

EPA is found preformed in cold-water fish (such as salmon, mackerel, and herring) and in the oils from such fish. Vegetable oils such as flax seed and canola contain alpha-linolenic acid, which in turn, can increase body EPA and 3-series prostaglandin levels.

Omega-6 fatty acids lead to both series 1 and 2 of prostaglandins. The omega-6 prostaglandin pathway can begin with Linoleic Acid (LA), which can be converted to gamma-linolenic acid (GLA) and then to dihomogamma-linolenic acid (DGLA). Some of the DGLA is converted to series 1 prostaglandins; other DGLA is converted (with the enzyme delta-5 desaturase) to arachidonic acid (AA). Of the AA, some is converted (with the enzyme cyclo-oxygenase) to series 2 prostaglandins; other AA is converted (with lipoxygenase) to inflammatory leukotrienes.

In the above omega-6 fatty acid metabolism stream, we can enter the stream at various points. For example, we can enter it at the Li-

noleic acid stage by ingesting Linoleic acid (LA) found in safflower, sunflower, hemp, soybean, walnut, pumpkin seed, sesame seed and flax seed. Safflower and sunflower are the richest source of linoleic acid.

Or we can enter it at the Gamma-Linolenic Acid (GLA) stage. Borage is the richest source of GLA with roughly 20%; black currant seed oil contains approximately 15% and evening primrose oil contains about 10% GLA.

One important role of EPA is that it may help to prevent the release of arachidonic acid (AA) from the membranes, thereby preventing the formation of PG2s. This is important because excessive PG2s are "bad" characters.

Also, the omega-3 fatty acids tend to block the synthesis of PG2 because omega-3 successfully competes with omega-6 fatty acids in the utilization of the delta-5 desaturase, which is the enzyme critical in the production of both EPA (in the omega-3 pathway) and arachidonic acid (in the omega-6 pathway).[1]

In terms of cellular membranes, EFAs

- are one of the constituents of all cellular membranes
- help to maintain the fluidity of cellular membranes

The above two features of EFAs are further explained in the section on PHOSPHOLIPIDS later in this article.

The conversion of linoleic acid and alpha-linolenic acids into the various compounds leading to the production of prostaglandins is made possible by vitamins B-3, B-6, C and the minerals zinc and magnesium. Particularly in the early stages of the above prostaglandin pathways, the conversion can be blocked by consumption of excessive alcohol and saturated and trans fatty acids.

Since EFAs play such a critical role in various functions of the body, it is reasonable that a deficiency of EFAs may cause many problems. On a chronic basis, an EFA deficiency can lead to high cholesterol levels, high blood pressure, cardiovascular disease, allergies, arthritis, multiple sclerosis and cancer. The levels of EFAs in people with these diseases are often low. Most of these people can prevent or reverse these conditions with appropriate supplementation of EFAs and the essential minerals and vitamins required for EFA metabolism.

Skin Conditions

For healthy skin, a number of factors need to be addressed:

1) The skin is a major organ of elimination in the body. When toxins are eliminated through the skin, it can become irritated. The best way to restrict this irritation is to avoid ingestion or exposure to toxins in the first place. Additionally, sufficient fiber in the diet and other lifestyle choices will tend to encourage some of these toxins to leave the body through organs of elimination other than the skin.

2) For healthy skin, the pores should be kept open. Sweating helps to ensure this.

3) The avoidance of an overabundance of saturated fat and the inclusion of sufficient essential fatty acids in the diet are important factors for healthy skin.

Acne is a skin condition characterized by blackheads, whiteheads and red cystules that form where hair follicles in the skin become blocked. It can be caused by such factors as too much saturated fat and too little of the EFAs. Within a total dietary supplement protocol, one tablespoon of flax seed oil per day is recommended for acne.[2]

Blackheads and Whiteheads

Skin pores can become clogged by fats that are not liquid and able to flow properly. Although sometimes white in color, these clogged pores can turn black when the oils and their pigments interact with sunshine and air.

Eczema is a chronic skin condition with the most common symptoms being dry, itchy skin. This inflammatory condition affects around five percent of the population and is often associated with allergies and/or a deficiency of EFAs, both omega-3 and omega-6. One of the causes of eczema is a decreased level of favorable prostaglandins (PG1 and PG3) as a result of a decrease in delta-6 desaturase of the fatty acid metabolic pathway.

Dietary recommendations involving fats include 1) avoiding sources of arachidonic acid, such as saturated animal fats, and 2) increasing consumption of cold-water fish. As part of a total dietary supplement protocol, evening primrose oil (4 – 6 grams per day in divided doses) and flax seed oil (one tablespoon per day) are recommended.[3,4]

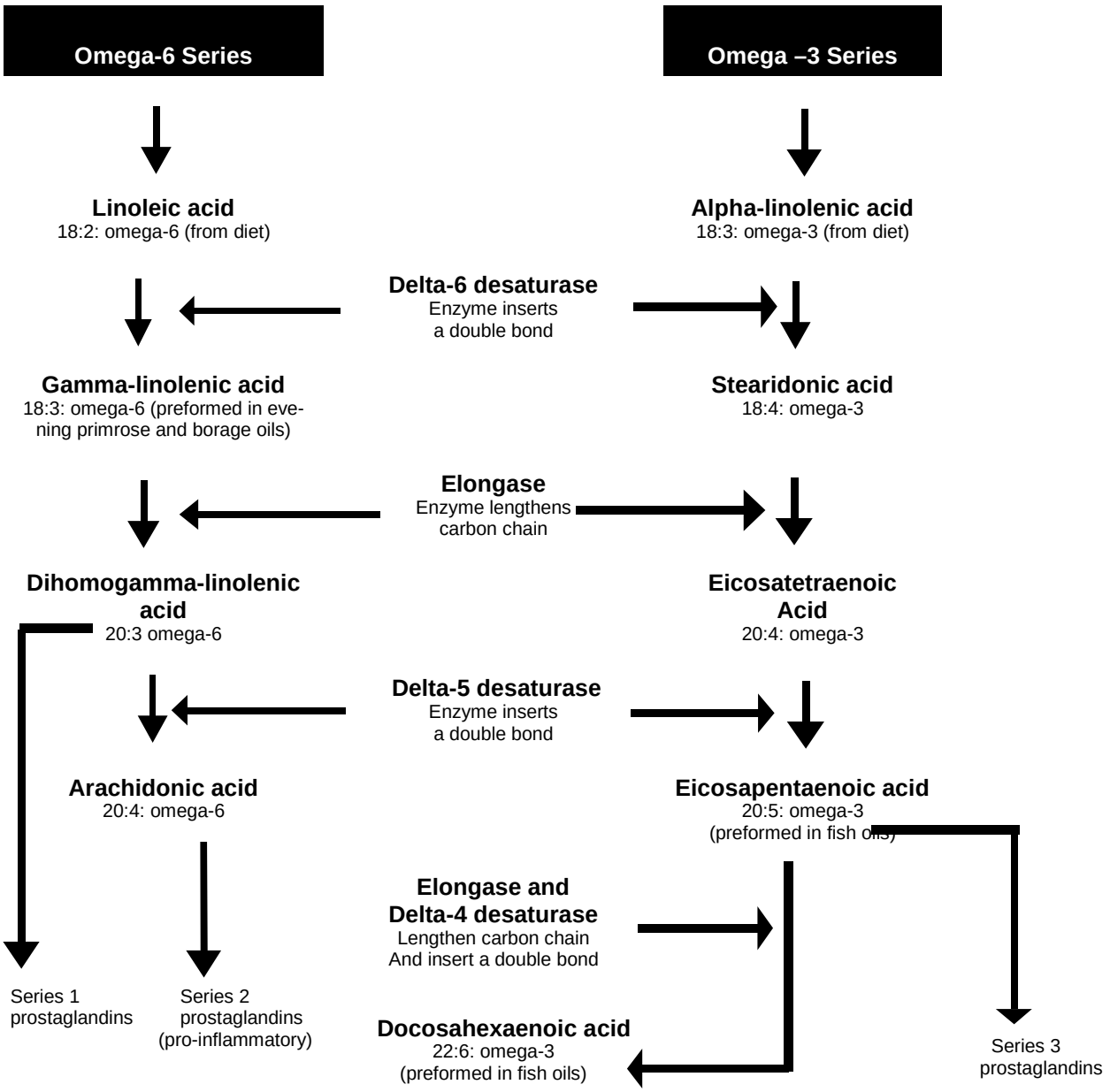
[1] Willis, A. Handbook of Eicosanoids: Prostaglandins and Related Lipids, Vol. 2, Boca Raton. CRC Press, 1989.

[2] Grafton, C et al. Essential fatty acid metabolites in plasma phospholipids in patient with ichthyosis vulgaris, acne vulgaris and psoriasis. Clin Exp Dermatol 1990 May; 15(3):174-176.

[3] Morse, PF, et al. Meta-analysis of placebo-controlled studies of the efficacy of Epogam in the treatment of atopic eczema. Relationship between plasma essential fatty acid changes and clinical response. Br J Dermatol 1989 Jul 121(1): 75-90.

[4] J. Wright and J. Burton, "Oral evening primrose oil

METABOLIC CONVERSION OF OMEGA FATTY ACIDS



Psoriasis is a common skin disorder characterized by thickened patches of inflamed skin. Among other supplementation, both omega-3 and omega-6 fatty acids are helpful in correcting faulty lipid metabolism, which is linked to psoriasis. Dietary recommendations involving fats include 1) avoiding sources of arachidonic acid, such as saturated animal fats, and 2) increasing consumption of cold-water fish. As part of a total dietary supplement protocol, flax seed oil (one tablespoon per day) is recommended.[5,6]

Dry Skin

Our skin becomes drier as we grow older. This is particularly a problem in parts of the world where the winters are cold. In this case, it is important to consume oils that flow easily in the cold, such as the omega-3 fatty acids. As part of a total dietary supplement protocol, flax seed oil (one tablespoon per day) is recommended.[5,6]

Heart Disease and Related Conditions

Regarding cardiovascular disease, omega-3 fatty acids have been shown in studies to:

* Help lower the LDL to HDL blood cholesterol ratio (See section on Cholesterol later in this article for discussion of mechanism.)[7,8]

* Lower levels of fibrinogen (a protein involved in the body's clotting system) through a process called fibrinolysis; omega-6 oils do not seem to have this effect. High fibrinogen levels are associated with cardiovascular disease.[9]

* Lowers the tendency of platelets to inappropriately clump together in the bloodstream. In a study on men with high cholesterol levels, the comparison was made between the effects of eating an equivalent amount of fish oil from whole cold-water fish versus a fish oil supplement. Consuming the whole fish produced a much greater effect than the fish oil supplement on reducing platelet stickiness and preventing clot formation.[10]

[5] Das UN, et al. Psoriasis: current concepts and new approaches to therapy. Med Hypotheses 1992 May; 38 (1):56-62.

[6] V. Ziboh, "Implications of dietary oils and polyunsaturated fatty acids in the management of cutaneous disorders." Arch Dermatol, 1989, 125(2):241-5

[7] Bjerve, K. S., et al. (1992). "Clinical studies with alpha-linolenic acid and long chain n-3 fatty acids." *Nutrition* 8:130-132.

[8] Simopoulos, A. P. (1991). "Omega-3 fatty acids in health and disease and in growth and development." *Am J Clin Nutr* 54:438-463.

[9] Raduck et al (1990) "The comparative effects of n-3 and n-6 polyunsaturated fatty acids on plasma fibrinogen level." J Am Coll Nutr 9:352-357.

[10] Cobias, L., et al (1991) Lipid, lipoprotein, and hemostatic effects of fish versus fish oil w-3 fatty acids in mildly hyperlipidemic males." Am J Clin Nutr 53:1210-1216.

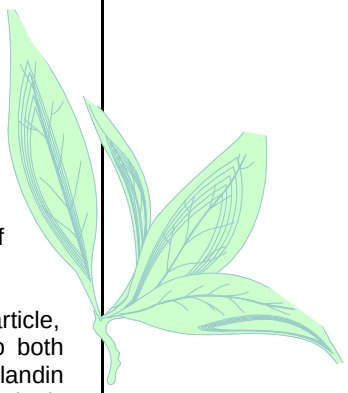
[11] Schmidt, E. B., and Dyerberg, J. (1994). "Omega-3 fatty acids. Current status in cardiovascular medicine." *Drugs* 47:405-424.

* Lowers blood pressure (high blood pressure is a major risk factor for a heart attack or stroke). This effect is probably due to a number of factors, including improved blood flow resulting from reduction in plaque in blood vessels.[11]

Many studies have focused on the diets of Eskimos in Greenland and Alaska and the diets of populations in fishing villages in Japan. In all of these studies, a high intake of fish and even high-fat blubber were shown to be important in preventing heart disease (and many other diseases as well). One Eskimo village in Greenland had a death rate from heart disease of only 3.5 percent, compared to as much as 50 percent among the people of Denmark who 1) are of the same genetic (Mongolian) stock as the Greenland Eskimos and 2) eat much less fish and much more vegetables, fruits and grains. The key to the Eskimos' health is the high level of omega-3 fatty acids in fat derived from marine sources.[12]

Allergies and Inflammatory Conditions

Omega-3 fatty acids play a major role in the allergic and inflammatory response because they are converted in the body to favorable prostaglandins and favorable leukotrienes—important mediators of inflammation.



As was previously discussed in this article, omega-6 fatty acids can be converted to both PG1 and PG2. The omega-6 prostaglandin pathway can begin with Linoleic Acid (LA), which can be converted to gamma-linolenic acid (GLA) and then to dihomogamma-linolenic acid (DGLA). Some of the DGLA is converted to PG1; other DGLA is converted to arachidonic acid (AA). Of the AA, some is converted (with the enzyme cyclo-oxygenase) to PG2; other AA is converted (with lipoxygenase) to inflammatory leukotrienes. Inflammatory leukotrienes are a major source of triggering in allergies and inflammatory conditions.

The following help to reduce inflammatory leukotrienes, increase favorable leukotrienes, and thereby help to improve allergies and inflammatory conditions:

- restricting the intake of omega-6 fatty acids, especially if a deficiency of vitamins C and B3 and zinc is likely to cause conversion to PG2 (bad) and bad leukotrienes versus conversion to PG1 (good)

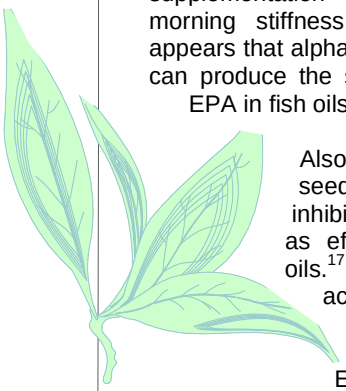
- supplementing the diet with omega-3 fatty acids (flaxseed oil) and the various vitamins and minerals that are critical in omega-3 fatty acid metabolism.[13]

[12] Niaki, S.K. (1987) The Omega Connection – The Facts About Fish Oils and Human Health. Esquire Books.
[13] Kelley, D. (1992) "Alpha linolenic acid and immune response." Nutrition 8:215-217.

Numerous clinical studies have demonstrated a therapeutic effect in the treatment of many chronic allergic and inflammatory diseases, including rheumatoid arthritis, asthma, psoriasis and lupus, when supplementing the diet with essential fatty acids.

Rheumatoid Arthritis

Several double-blind, controlled studies of rheumatoid arthritis patients using EPA supplementation have demonstrated less morning stiffness and tender joints.[14,15] It appears that alpha-linolenic acid in flax seed oil can produce the same kind of results as the EPA in fish oils.[16]



Also, research indicates that flax seed oil supplementation can inhibit the autoimmune reaction as effectively as EPA from fish oils.[17] However, alpha-linolenic acid will not be as effective as EPA if the conversion of alpha-linolenic acid to EPA is blocked significantly. To reiterate, alpha-linolenic acid eventually can be converted through several enzymatic steps to eicosapentaenoic acid (or EPA) if several nutritional conditions are met:

- sufficient vitamins B6, niacin, C; magnesium and zinc are present
- not too much trans fatty acids, saturated fats, or alcohol are present

Multiple Sclerosis

In multiple sclerosis (MS), there is a destruction of the myelin sheath that surrounds and insulates the nerves. It is believed that people with MS have a defect in essential fatty acid absorption or transport, which results in a functional deficiency state. In addition, because consumption of saturated fats increases the requirements of essential fatty acids, a relative deficiency state exists in many cases even if the level of essential fatty acids in the diet would be sufficient under normal circumstances.

[14] Kremer, J., et al. (1985). "Effects of manipulation of dietary fatty acids on clinical manifestation of rheumatoid arthritis." *Lancet J*anuary 26:184-187.
[15] Sperling, R., et al. (1987). "Effects of dietary supplementation with marine fish oil on leukocyte lipid mediator generation and function in rheumatoid arthritis." *Arthritis Rheum* 30:988-997.
[16] Mantzioris, E., et al. (1994). "Dietary substitution with alpha-linolenic acid-rich vegetable oil increases eicosapentaenoic acid concentrations in tissues." *Am J Clin Nutr* 59:1304-1309.
[17] Kelley, D. S. (1992). "Alpha-linolenic acid and immune response." *Nutrition* 8:215-217.

This defect in essential fatty acid metabolism in MS involves deficiencies of the omega-3 oils, which play an important role in the structure and function of myelin. Myelin is the material that coats and insulates the nerve fibers. A deficiency of alpha-linolenic acid and other omega-3 fatty acids can result in permanently impairing the formation of normal myelin.[18,19]

In a long-term study, a diet low in saturated fats and high in essential fatty acids tended to halt the disease process in MS. Of the MS patients who were on the above diet, only five percent died within the study period; of the MS patients who were on a diet of normal (for the subjects) amounts of saturated fats and EFAs, 80 percent died by the end of the study period. It appears that both omega-3 and omega-6 fatty acids are helpful in dealing with MS, but that the omega-3 may be more essential than the omega-6.[20]

Diabetes

Non-Insulin Dependent Diabetes Mellitus (referred to as "type II diabetes") usually occurs after age 40. Insulin levels are typically elevated, indicating a loss of sensitivity to insulin by the cells of the body. Obesity and the type of dietary fat consumed are major contributing factors to this loss of insulin sensitivity. Type II diabetes is associated with an abundance of saturated fat and a relative insufficiency of essential fatty acids.[21]

One of the key reasons appears to be the fact that such a dietary pattern leads to reduced membrane fluidity, which, in turn, causes reduced insulin binding to receptors on cellular membranes or reduced insulin action. Omega-3 fatty acids seem to improve insulin action.[22]

Animal studies have also shown that omega-3 fatty acids prevent the development of insulin resistance.[23] All of this evidence appears to indicate that altered membrane fluidity may play a critical role in the development of type II diabetes.

The topics of cell membranes and membrane fluidity are discussed in greater depth in the Phospholipids section of this article.

[18] Cunane, S. C. (ed.) (1991). Symposium Proceedings: Third Toronto Essential Fatty Acid Workshop on Alpha-Linolenic Acid in Human Nutrition and Disease. May 17-18, 1991, University of Toronto, Toronto, Ontario, Canada. *Nutrition* 7:435446.
[19] Simopoulos, A. P. (1991). "Omega-3 fatty acids in health and disease and in growth and development." *Am J Clin Nutr* 54:438-463.
[20] Swank, R. L., and Pullen, M. H. (1977). *The Multiple Sclerosis Diet Book.* Doubleday, Garden City, NY.
[21] Pelikanova, T., et al. (1991). "Fatty acid composition of serum lipids and erythrocyte membranes in type 2 (non-

insulin-dependent diabetic men)." *Metab Clin Exp* 40:175-180.

[22] Pelikanova, T., et al. (1989). "Insulin secretion and insulin action are related to the serum phospholipid fatty acid pattern in healthy men." *Metab Clin Exp* 38:188-192.

[23] Storlien, L. H., et al. (1991). "Influence of dietary fat composition on the development of insulin resistance in rats: Relation to muscle triglyceride and omega-3 fatty acids in muscle phospholipid." *Diabetes* 40:280-289.

Prostaglandin Synthesis

The production of series 1, 2, and 3 families of prostaglandins is dependent on the type and quality of fats and oils we consume. The challenge lies in consuming an approximate ratio of omega-6 to omega-3 fatty acids that will produce a favorable production of the beneficial series 1 and 3 prostaglandins, while managing the over-production of the potentially harmful prostaglandin 2 series.

From the point of view of production of favorable prostaglandins, the ideal ratio of omega-3 to omega-6 fatty acids is 1:4.[24] However, most Americans consume omega-6 fatty acids in quantities much greater than 4 times the amount of omega-3 fatty acids. In order to create an optimal omega-6 to omega-3 ratio in the body, we want to:

- reduce or eliminate the omega-6 oils that are of low quality (see the sections on hydrogenation and trans fatty acids)
- increase levels of omega-3 fatty acids

Many people have an omega-3 deficiency, both in an absolute sense and relative to the omega-6 fatty acids. For these people, a short-term strategy is to consume flax seed oil supplementation or healthy doses of cold-water fish such as salmon (or fish oils derived from these fish) to bring the person into balance.

Fish oils are high in omega-3, but have no omega-6. Flax seed oil has an omega-3 to omega-6 fatty acids ratio of approximately 3:1. Flax seed oil has about 55% omega-3 fatty acids, which is about twice the percentage omega-3 fatty acids found in cold-water fish oils.

As mentioned above, the ideal omega-3: omega-6 ratio is 1:4.

Therefore, cold-water fish (or fish oils derived from such fish) or flax seed oil is best used with (and to balance) a diet in which omega-6 fatty acids are present in quantities significantly greater than four times the amount of omega-3 fatty acids (as is very commonly the case).

For proper supplementation on a daily basis, one to two tablespoons of liquid flax seed oil - or 6 to 12 1,000 mg capsules - provide most adults with optimal levels of omega-3 fatty acids. The flax seed oil found in capsules should be organic and unrefined, sold and packaged in a dark glass bottle, kept from oxygen and light as much as possible, stored in a refrigerator, and used within six weeks.

[24] Schlomo, Y. and Carasso, R. L. (1993). "Modulation of learning, pain thresholds, and thermoregulation in the rat by preparations of free purified alpha-linolenic and linoleic acids: Determination of the optimal w3-to-w6 ratio." *Proc Natl Acad Sci* 90:10345-10347.

Flax Seed Oil

Flax seed oil is a very rich and cost-effective source of particularly alpha-linolenic acid (omega-3) at 55-60%, and is also a good source of linoleic acid (omega-6) at 15-20%. In fact, the Latin word for flax, linum, is the basis for the words, “linolenic” and “linoleic.” In addition, flax seed oil contains about 18% monounsaturated oleic acid, which will be discussed in a later section.

Fresh, unrefined flax seed oil contains lecithin and other phospholipids that help emulsify fats and oils for easier digestion. It also contains carotene and vitamin E, which help prevent oxidation of the oil.

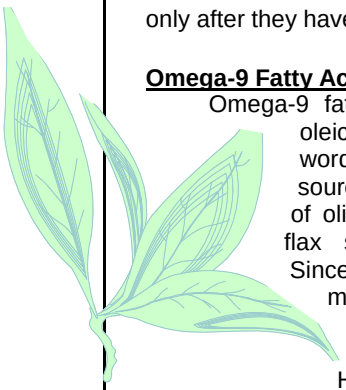
Flax seed oil can be used alone or as part of an oil blend in food preparation. However, the essential fatty acids in flax seed oil are damaged by heat; therefore flax seed oil should not be used for frying, deep-frying, or other high-heat uses. Use in salads and other cold dishes such as tabouleh, humus (mixed 50:50 with olive oil), protein shakes and marinated vegetables. It can be mixed with skim milk yogurt, or with butter to make a softer, more nutritious spread. Flax seed and oil blends can be used on hot vegetables, in hot cereals, on pasta (it may be mixed with olive oil for taste), in mashed potatoes, on hot corn and on toast, added just before eating. Flax seed oil can be blended with butter in approximately a 50:50 ratio to create a very healthy substitute for margarine. Flax seed oil can be mixed with various juices, such as orange or tomato for easy consumption.

However, there are good reasons to consume the flax seed freshly ground, without having the oil separated from it. One reason is that the whole flax seed contains lignans, which have anti-viral, anti-fungal, anti-bacterial, and anti-cancer properties. Flax contains 100 times the quantity of lignans as the next best source, which is wheat bran. Flax oils that are high in lignans tend to be more viscous, cloudy and have higher amounts of sediment.

Since only two percent of the lignans found in flax seeds end up in flax seed oil (the other 98% remaining in the seed meal), it is best to consume the freshly ground flax seed. Ground flax seed also contains mucilage, fiber and proteins that are not found in the oil. Mucilage and fiber are beneficial relative to fats in that they tend to lower cholesterol levels. Of course, proteins are a macro-nutrient category, another topic. Another reason to consume the freshly ground flax seed is that the oil portion will be as

fresh as possible and the fragile essential fatty acids will not have much of a chance to degrade due to exposure to air, light and other factors. (See Lipid Peroxidation section.)

Flax seeds can be easily ground at home using a small grinder, such as one sold for grinding coffee beans. Only an amount that can be used immediately should be ground. Four to six tablespoons of freshly ground flax seed is a good daily amount. Having a pleasant nutty taste when freshly ground, it can be sprinkled over many different types of food, including salads and various cold dishes (and hot dishes only after they have been cooked).



Omega-9 Fatty Acid

Omega-9 fatty acid is monounsaturated oleic acid; "oleic" comes from word "olive." Good dietary sources of oleic acid are the oils of olives (60-80% oleic acid) and flax seed (15-20% oleic acid). Since the human body can also make oleic acid from saturated fatty acids, oleic acid is not considered to be essential. However, oleic acid is important because it appears that it helps to keep our arteries flexible and helps protect LDL cholesterol from oxidizing.[25]

It is not known precisely how oleic acid produces these benefits. It is possible that olive oil (used in most of the oleic acid studies) contains (if it is unrefined) many non-lipid elements (such as polyphenol) which may contribute to this effect. Since unrefined (also called "virgin") olive oil has such non-lipid elements which are taken out or destroyed during refining, it is best to buy and consume olive oil that is "virgin" or "extra virgin."

Hydrogenation and Trans Fatty Acids

Hydrogenation of oils is a process in which hydrogen molecules are unnaturally added to naturally unsaturated oils to make them more saturated. This hydrogenation results in such processed items as margarine and shortening. It creates an item that is stable in the presence of light and oxygen, whereas the unsaturated oils are unstable. Partially-hydrogenated fats tend to be semi-solid and completely hydrogenated fats tend to be solid.

However, the hydrogenation process makes the oil less healthy. First, the more saturated the fat, the less nutritious it is. Second, hydrogenation creates trans fats, fatty acid molecules that get twisted out of shape during heating. In a trans fatty acid, the configuration of the fatty acid molecule is changed from a cis (or C-shaped) molecule to a molecule on a straight line.

[25] "Dietary olive oil reduces LDL uptake by macrophages and decreases the susceptibility of the lipoprotein to undergo lipid peroxidation." Annals of Nutr & Metab. 1993;37(2):75.)

Trans fatty acids and hydrogenated oils have been associated with a number of disorders, including increased levels of harmful cholesterol in humans, heart disease, obesity, diseases related to the immune system, low birth weight in infants, low quality and volume of breast milk, abnormal sperm production and decreased testosterone in men and prostate disease. Margarine and other hydrogenated vegetable oils raise harmful LDL cholesterol, lower beneficial HDL cholesterol levels, interfere with essential fatty acid metabolism and may cause certain cancers.[26,27] Therefore, it is desirable to eliminate the intake of margarine and other processed foods containing trans fatty acids and partially-hydrogenated oils.

Hopefully, the food processing industry will be forced to disclose the levels of trans fats in all processed foods and to gradually phase out the hydrogenation process that produces trans fatty acids.

Lipid Peroxidation

Fats and oils become rancid/oxidize when exposed to heat, oxygen and sunlight. Sunlight produces free radicals in oils and greatly hastens the reaction of oils with oxygen, creating rancid oil. Some of the by-products of lipid peroxidation are harmful to human health.

The best oils for cooking are canola and olive oil because these oils are composed primarily of oleic acid, a monounsaturated oil that is more resistant to the damaging effects of heat and light compared to such highly polyunsaturated oils as corn, safflower and soy. When the polyunsaturated oils are exposed to heat or light, the chemical structure of the essential fatty acids can be changed to lipid peroxides.

To avoid the above oxidative and free-radical effects of oxygen and sunlight on oils, it is ideal to press and package fresh oils in the dark, in the absence of oxygen, and with minimal heat. Vitamin E should be added to oils as an antioxidant. Then the product should be stored in tightly-sealed, opaque containers, and the shelf life noted on the packaging. Store-bought, extracted EFA oils (including flax seed, borage and evening primrose oils) are easily oxidized, so they should never be heated and are best stored in the refrigerator and consumed by the expiration date.

[26] Enig, M. G. (1993) "Trans fatty acids: An update." Nutrition Quarterly 17(4):79-95

[27] Mensink, R. P., and Katan, M. B. (1990). "Effect of dietary trans fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects." New Engl J Med 323:439-445.

In addition, it is important to take antioxidant supplements to decrease the chance that fatty acids and other lipids, once in the human body, will oxidize. Such antioxidants include vitamins C and E, carotene, and glutathione, selenium, zinc, manganese, and oligomeric proanthocyanidins found in grape seed extract and pine bark extract. Vitamin C captures free radicals, preventing them from doing damage. Vitamin C also recharges vitamin E (which, in turn, recharges carotene), which neutralizes free radicals in oil-soluble membranes.

Vitamin C also recharges glutathione, which neutralizes free radicals that have passed through the membrane into a cell. Therefore, vitamin C is perhaps the most important antioxidant in our body; increased intake of vitamin C plays a leading role in preventing and reversing atherosclerosis, heart attacks and strokes.

The cell membranes of the human body are constantly under attack by free radicals and pro-oxidants. These highly reactive molecules can bind to and destroy cellular membranes as well as other cellular components. The normal molecule is made up of stable atoms that have paired electrons spinning around them. If one electron is knocked out of orbit from one of the pairs, then the atom (and the molecule that it is part of) becomes unstable and is called a free radical. To restore stability, the molecule has a strong tendency to steal an electron from a nearby molecule; this process is called "oxidation." In turn, the just-robbed molecule has a strong tendency to steal an electron from a nearby molecule. In a very quick chain reaction, many molecules can become free radicals. The targets for these "robberies" by free radicals include lipids and proteins. Free radical damage of lipids is called "lipid peroxidation." [28]

One example of lipid peroxidation is the oxidative damage to LDL cholesterol, which is the first step in a series of events leading to atherosclerosis. This is explained further in the CHOLESTEROL section.

PHOSPHOLIPIDS

Phospholipids are a second category of lipids making up less than 5 percent of the total lipids in the human body. In addition to two fatty acids, a phospholipid molecule contains a phosphate group.

The functions of phospholipids include:

- help maintain the structural integrity and fluidity of cell membranes
- act as an emulsifier

[28] Borek, Carmia. Maximize Your Health-Span with Antioxidants. Keats Publishing, 1995. pp14-15.

- being components of brain and nervous-system tissue
- involved in neurotransmission

The first of the above roles will be discussed next. The other three roles will be discussed within the context of Phosphatidyl choline.

The Role of Phospholipids in Cell Membranes

Phospholipids form double-layered membranes; the skin that surrounds every living cell of all living organisms, including animals and humans. In addition, phospholipids form skins around tiny organs within our cells called organelles.

Phospholipids have many functions within our membranes. They (with help from proteins) determine which substances can enter cells from outside, and which substances will exit from within cells. These substances include water, electrolytes and other important nutrients. Phospholipids help hold proteins in place in membranes to fulfill structural, enzymatic, and transport functions.

The middle carbon of glycerol molecules in phospholipids usually holds an essential fatty acid (EFA) which, being highly unsaturated, is bent and cannot be tightly packed. It takes up more space than a straight saturated fatty acid (SFA) molecule, and keeps membranes from hardening. In this manner, phospholipids keep cell membranes fluid, enabling proteins within them to move freely around the surface of the cell to perform vital functions. Phospholipids also store each cell's supply of essential fatty acids (EFAs).

Either a saturated or monounsaturated fatty acid is usually found on the outside carbon of glycerol in phospholipids. The saturated fatty acid provides membrane rigidity, and also separates highly unsaturated fatty acids from one another, preventing them from negatively reacting (cross-linking) with one another.

Besides phospholipids and proteins, our membranes contain cholesterol, which fine tunes membrane fluidity under constantly fluctuating conditions of food fat intake. In the later section of this article on Cholesterol, the interplay between EFAs and cholesterol in the cell membranes will be further discussed.

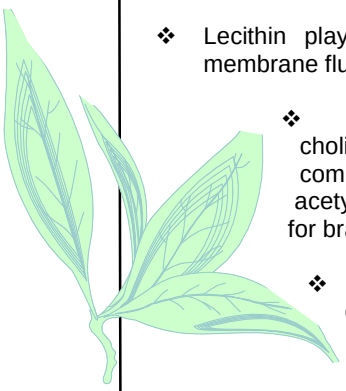
The phosphate group ensures that each

molecule of phospholipid lines up in the same direction on a water surface, with the precise regularity required to form the membrane.

Several other chemical groups -- choline, inositol, serine, or ethanolamine can be attached to phosphate groups. For instance, Phosphatidyl choline is a phospholipid with a choline group attached to its phosphate group.

Phosphatidyl Choline

Phosphatidyl choline is an abundant phospholipid in our diet and in our body. Also referred to as lecithin, this phospholipid has many functions.



- Lecithin plays an important role in cell membrane fluidity (as explained previously)
- Lecithin is a source of choline. Choline is a critical component of the neurotransmitter acetylcholine, which is important for brain and nerve function.
- Lecithin is an important component of bile, which breaks down food fats into small droplets (emulsifies them), to increase their surface area, allowing enzymes to more easily digest the fats.
- Lecithin helps to keep cholesterol from oxidizing by coating it; non-oxidized cholesterol is less likely to attach to the inside of blood vessels, as will be explained in the Cholesterol section of this article. Lecithin makes up 22% of both the high density (HDL) and low density lipoprotein (LDL) cholesterol-carrying vehicles in our blood.

CHOLESTEROL

Cholesterol is a major player in a third category of lipids called "sterols." From a dietary point of view, cholesterol is found in the saturated fats of animals and food products derived from them, such as milk and eggs. Organ meats and eggs contain the highest levels of cholesterol; red meat products are next highest; dark meat chicken, (then white meat) is next; fish generally have the lowest cholesterol content of the flesh foods. Plants never contain cholesterol, but they do contain other sterols.

Cholesterol is also made by the human body. For about 70 percent of the population, increasing dietary cholesterol leads to a decrease in production of cholesterol by the body. This allows blood levels of cholesterol to remain relatively constant, regardless of dietary intake. For the other 30 percent of the population, the body's production of cholesterol is not lowered when dietary levels are increased.

Most of the bad reputation of fats comes from the public's perception of cholesterol. In fact, cholesterol has many useful functions in the human body. As we will explore in greater depth later in this article, cholesterol becomes a health problem for most people only

- When the cholesterol becomes oxidized,
- When certain essential nutrients and fiber are not present in the body in sufficient quantities
- When very large quantities of cholesterol are consumed.

Useful Functions of Cholesterol

1) It is an important component of cell membranes. The basic function of the cell membrane is to serve as a selective barrier that regulates the passage of certain materials in and out of the cell. When there is a disturbance of structure or function of the cell membrane, there is a disruption of homeostasis (natural balance).

   In a careful balancing act to create appropriate membrane fluidity, the cells use varying amounts of cholesterol and unsaturated fatty acids. Cholesterol and saturated fatty acids make cell membranes more solid; the essential fatty acids make membranes more fluid. This role in cell membrane function is so important that each cell has the ability to produce its own cholesterol.

   In addition to phospholipids and proteins, our membranes contain cholesterol, which fine tunes membrane fluidity under constantly fluctuating conditions of food fat intake. A diet rich in EFAs (which are fluid) means that more cholesterol (which is rigid) will be built into membranes to balance their fluidity. This is one reason why EFAs tend to lower blood cholesterol levels. A diet high in saturated fats (which are hard) means more cholesterol will be removed from membranes back into our blood. For this reason, saturated fatty acids tend to raise blood cholesterol levels.

2) Cholesterol is a starting material for the synthesis of many important compounds in the body, such as bile, the sex hormones (testosterone, progesterone and estrogen), the adrenal hormones (including cortisol) and vitamin D3.

   Blood cholesterol, an area in which cholesterol has both a good and bad connotation, is closely associated with lipoproteins. Lipoproteins are protein-wrapped molecules that carry cholesterol and fatty acids throughout the body. The three types of lipoproteins are: very low-density lipoprotein (VLDL), low-density lipoprotein (LDL), and high-density lipoprotein (HDL).

LDL and VLDL are molecules that transport cholesterol and triglycerides from the liver to all the cells of the body via the bloodstream. Since they have a causal role in atherosclerosis and cardiovascular diseases, we want to keep LDL/VLDL levels low.

HDL circulates in the bloodstream, collects excess cholesterol, and returns it to the liver. Since HDL has a preventive role in atherosclerosis and cardiovascular diseases, we want to keep HDL levels high. We want to maximize the ratio of HDL to LDL/VLDL. Put differently, we want to minimize the LDL: HDL ratio.

Certain types of dietary fiber lower blood cholesterol (psyllium and bran are the best). Blood cholesterol attaches to the fiber, and is carried out of our body, preventing cholesterol from being reabsorbed into our body from our intestines.

Oxidized Cholesterol

Research shows that only oxidized LDL cholesterol damages arteries and leads to atherosclerosis (the buildup of fatty deposits in the innermost layer of the artery wall). When LDL oxidizes, it breaks down into particles. The immune system recognizes these decaying LDL particles as a threat to the body's health. In response, macrophages and other immune cells swallow up these decaying LDL particles. The engorged immune cells become imbedded in the artery wall, where they start to form plaque. This is the beginning of atherosclerosis. In the beginning, the imbedded immune cells are referred to as "foam cells." Later in the process, a "fatty streak" forms. This process can eventually lead to the buildup of plaque so thick that it blocks blood flow in the arteries.[29]

Vitamins C and E, carotene, selenium and glutathione are antioxidants that normally prevent and repair oxidative damage in our bloodstream and cells. If the levels of these antioxidants become too low, cholesterol and fats become oxidized and cause damage to arteries.

Homocysteine

Another factor that can cause heart disease is a buildup of homocysteine in the body. Homocysteine is produced normally in the human body from the amino acid methionine. Under normal conditions, homocysteine is quickly either converted with the help of vitamin B-6 into cystathionine (a harmless substance), or recycled with the help of vitamin B-12 or folate (folic acid) into methionine (a harmless substance). The problem occurs in the following scenario:

1) there is an inadequate supply of vitamin B-6, B-12 and/or folate in the diet
2) the homocysteine does not get converted into cystathionine or recycled into methionine
3) the homocysteine builds up in the bloodstream
4) high blood levels of homocysteine cause a fibrous substance in the blood called proteoglycans to release a substance that appears to attack the inside of blood vessel walls

[29] McDougall, John. The McDougall Program for a Healthy Heart. Penguin Books. p27

5) the area of the blood vessel that is injured is covered with cholesterol in an attempt to heal it
6) the cholesterol deposits can grow in size, beginning the process of arteriosclerosis
7) this process can continue to the point where the clot can block blood flow, causing a heart attack or stroke.

There is significant evidence that high homocysteine levels are associated with high incidence of heart disease. In a study involving 15,000 physicians as subjects, homocysteine levels 12 percent higher than average were associated with a risk of heart attack 340 percent higher than the risk of heart attack among men with lower homocysteine levels.[30]

Meeting even the RDA for vitamins B-6 (2 mg for adult men), B-12 (2 mcg), and 1-5 mgs per day of folate (folic acid) should be sufficient to prevent the buildup of homocysteine in most people. People who usually need higher than RDA levels include alcoholics, people with malabsorption problems, and the elderly.

Lp(a) and Its Adhesive Protein Apo (a).

A lipoprotein known as Lp(a), which looks like LDL but carries an adhesive repair protein known as apo(a), has recently been found to be a strong risk factor for atherosclerosis. In combination with other repair proteins (such as fibrinogen), apo(a) thickens our arteries. When this process gets out of control, it can cause atherosclerosis. Vitamin C (and possibly other antioxidants) lowers apo(a) and fibrinogen/fibrin levels in our blood. Omega-3 fatty acids also lower blood fibrinogen/fibrin levels, and preliminary findings indicate that they also lower blood apo(a). Traditional cholesterol measurements have lumped LDL and Lp(a) together as LDL. However, LDL appears to be only a weak risk factor when it is considered to be distinct from Lp(a) / apo(a).[31]

Some of the population has what is called Syndrome X, a cluster of obesity/weight gain, diabetes/hypoglycemia, high LDL, low HDL, high blood pressure, high blood sugar and atherosclerosis. These people should make a special attempt to minimize the intake of refined sugars/starches, saturated fats and cholesterol; and to increase intake of EFAs, dietary fiber and the various vitamins and minerals known to improve overall health.

[30] Stampfer, M.J. et al. "A prospective study of plasma homocysteine and risk of myocardial infarction in U.S. physicians," JAMA 268(7) August 1992:877-81.
[31] Rath, M. & Pauling, L. Solution to the Puzzle of Human Cardiovascular Disease. *Journal of Orthomolecular Medicine,* Vol. 6, 3&4, pp.125 - 146. 1991.

STRATEGIES FOR MAXIMIZING THE HEALTH BENEFITS OF FATS AND OILS AND FOR MAXIMIZING OVERALL HEALTH

* Consume omega-3 fatty acids in the form of high-quality flax seed oil, freshly-ground flax seeds, cold-water fish or fish oil; and omega-6 fatty acids from borage oil and
* Minimize consumption of saturated fats. Eliminate hydrogenated fats and refined oils.
* Avoid refined sugars and starches.
* Eat fresh fruits and vegetables often for their antioxidant (and other) benefits and supplement with various antioxidants.
* Exercise regularly; very important for raising HDL levels (and for many other reasons).
* Increase fiber intake with good sources such as psyllium, flax seeds, whole grains, fruits, vegetable skins. Avoid products high in sugar and artificial sweeteners.