Facts about Fats

Fats and Fatty Acids

Most of us are bombarded with information about fats (much of it conflicting or confusing) and the healthiest way to eat. The terms "saturated fats," "omega-3 fats," and "trans fats" are familiar parts of our collective vocabularies. But, what do these terms really mean and how are they significant in terms of eating healthy and appropriate way?

Fats vs. Fatty Acids

The terms "fats" and "fatty acids" are often used interchangeably in lay literature and by news media. In fact, fatty acids are sub-units of fats. Most of the common fats that we eat and the fat we store in our body are technically called ACYLGLYCEROLS which are fatty acids (acyl group) linked to an alcohol (glycerol) via an ester bond (connects acid + alcohol by eliminating a water molecule).

Acylglycerols (Fats) can have:

1 fatty acid (acyl) group + glycerol: and are called mono-acylglycerol or monoglycerides
2 fatty acid (acyl) groups + glycerol: and are called di-acylglycerol or di-glycerides
3 fatty acid (acyl) groups + glycerol: and are called tri-acylglycerol or TRIGLYCERIDES

Monoglycerides and di-glycerides are metabolic intermediates and do not appear in large concentrations in food or in our body. Hence, TRIGLYCERIDES are the MAJOR Acylglycerol (FAT) in our foods and in our bodies. Although almost all of the fatty acids we eat and which we store in our bodies are triglycerides, fatty acids are also incorporated in all cell membranes as compounds called PHOSPHOLIPIDS. Further, when fats are broken down (the ester bond cleaved) and taken out of your fat cells and transported in the bloodstream, they are called FREE FATTY ACIDS. In order for a fatty acid to travel (be soluble) in a liquid (your bloodstream), it must be bound to a protein. Free fatty acids are bound to albumin, the major plasma protein in blood.

Fatty Acids

Fatty acids fall into one of three major categories:

- SATURATED fatty acids
- MONOUNSATURATED fatty acids
- POLYUNSATURATED fatty acids

Much of the confusion about fatty acids stems from multiple systems of naming these molecules. Fatty acids can have common names, systematic names and numerical names. Most commonly fatty acids are referred to by their common names and numerical names.

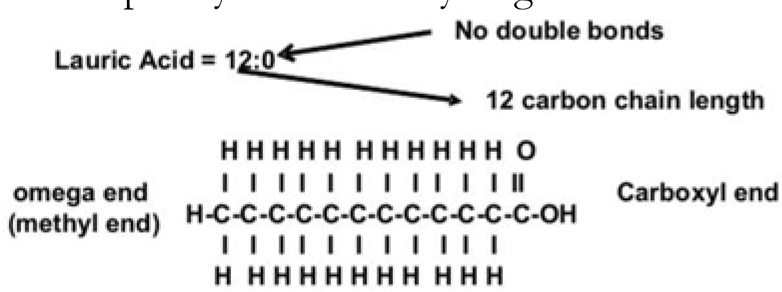
Saturated Fatty Acids

Saturated fatty acids most frequently occur in higher concentrations in animal foods such as butter, cheese, and fatty meats, however there are certain exceptions to this rule, and plant derived fats such as coconut and palm oils are also extremely high in saturated fatty acids. In fatty foods the most common saturated fatty acids are lauric acid (12:0), myristic acid (14:0), palmitic acid (16:0) and stearic acid (18:0). Excessive consumption of 12:0, 14:0 and 16:0 elevate blood concentrations of total and LDL cholesterol and increase your risk for heart disease. Stearic acid (18:0) is neutral and neither raises nor lowers blood cholesterol. Below is a list of the common and numeric names for saturated fatty acids that may occur in foods. Notice that most saturated fatty acids are even numbered. Odd numbered saturated fatty acids rarely are present in foods.

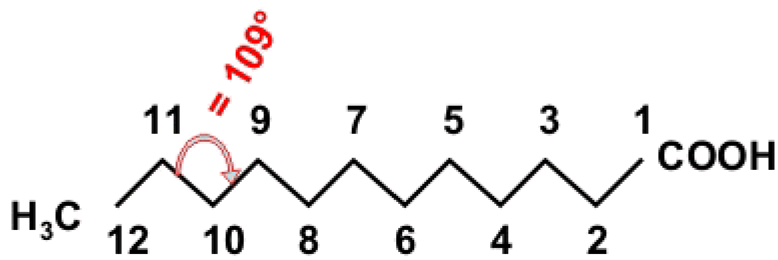
Common Name	Numeric Name
Butyric acid	4:0

Caproic acid	6:0
Caprylic acid	8:0
Capric acid	10:0
Lauric Acid	12:0
none	13:0
Myristic Acid	14:0
none	15:0
Palmitic Acid	16:0
Margaric acid	17:0
Stearic Acid	18:0
none	19:0
Arachidic acid	20:0
Behenic acid	22:0
Lignoceric acid	24:0

Saturated fatty acids (and all fatty acids) are comprised of chains of carbon atoms connected to one another by chemical bonds. The numeric name therefore represents the number of carbon atoms within the saturated fatty acid chain. Below is a schematic diagram of lauric acid or 12:0. Lauric acid is labeled 12:0 because it is 12 carbon atoms in length, and it contains no double bonds (=), but only single bonds (-) linking the carbon atoms. Note that there are two ends to all fatty acids, one called the omega end containing a methyl (CH_3) group and one end containing a carboxyl (COOH) group. Lauric acid and all saturated fats are "saturated" because the carbon atoms are completely filled with hydrogen atoms.



The schematic diagram above is not precisely correct because it does not show the correct angle of the carbon to carbon bonds which really is 109 degrees rather than 180 degrees. In the diagram below you see a geometrically correct diagram of lauric acid. Note that each carbon atom is numbered starting from the carboxyl (COOH) end of the fatty acid. The geometrical configuration of the carbon to carbon bonds (109 degrees) is important because it determines the shape of the fatty acid, particularly as we consider monounsaturated and polyunsaturated fatty acids.



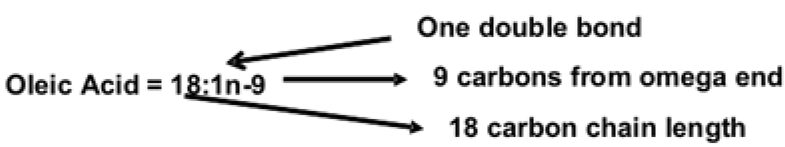
Monounsaturated Fatty Acids

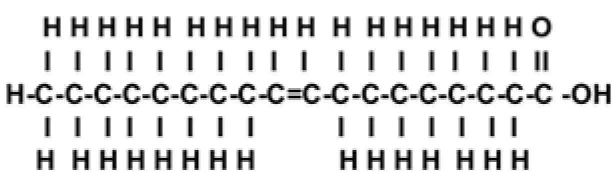
Monounsaturated fatty acids most frequently occur in higher concentrations in plant foods such as olive oil, most nuts, and avocados. Although marrow from animal bones is infrequently consumed in the U.S., it is also a good source of monounsaturated fats. When contrasted to saturated fatty acids, dietary monounsaturated fatty acids are healthful because they lower blood cholesterol concentrations. Below is a list of the common and numeric names for monounsaturated fatty acids that may occur in foods. The most common monounsaturated fatty acid in both plant and animal foods is oleic acid (18:1). As was the case with saturated fatty acids, most monounsaturated fatty acids are even numbered. Odd numbered monounsaturated fatty acids are infrequently present in foods.

Common Name	Numeric Name
Myristoleic acid	14:1
none	15:1
Palmitoleic acid	16:1

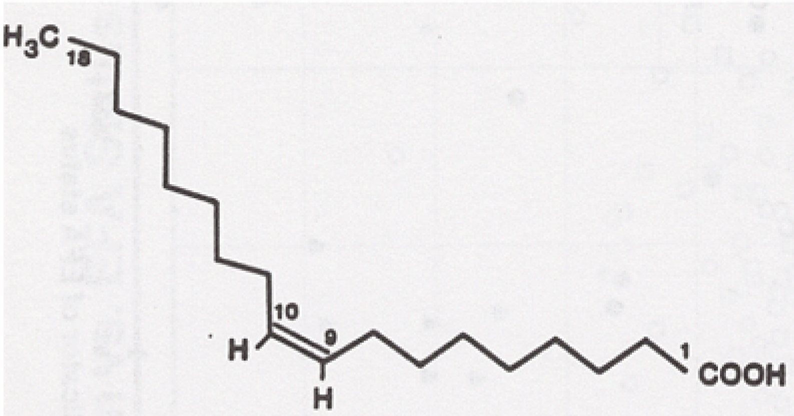
none	17:1
Oleic Acid	18:1
Gadoleic acid	20:1
Erucic acid	22:1
Nervonic acid	24:1

Monounsaturated fatty acids contain a single double (=) bond between two carbon atoms. The naming scheme for monounsaturated fatty acids follows that for saturated fatty acids. Oleic acid (18:1) means that the fatty acid is 18 carbon atoms in length and there is a single (:1) double bond. When a single double bond occurs in a fatty acid, it is useful to know the position of the double bond. Hence oleic acid can be further labeled 18:1n-9, meaning that there is a single double bond, 9 carbon atoms from the omega (n) end of the molecule. Note that the numbering scheme for double bonds starts at the omega or methyl end of the fatty acid whereas the numbering of carbon atoms starts from the carboxyl end of the carbon backbone. Below is a schematic diagram of oleic acid or 18:1n-9.

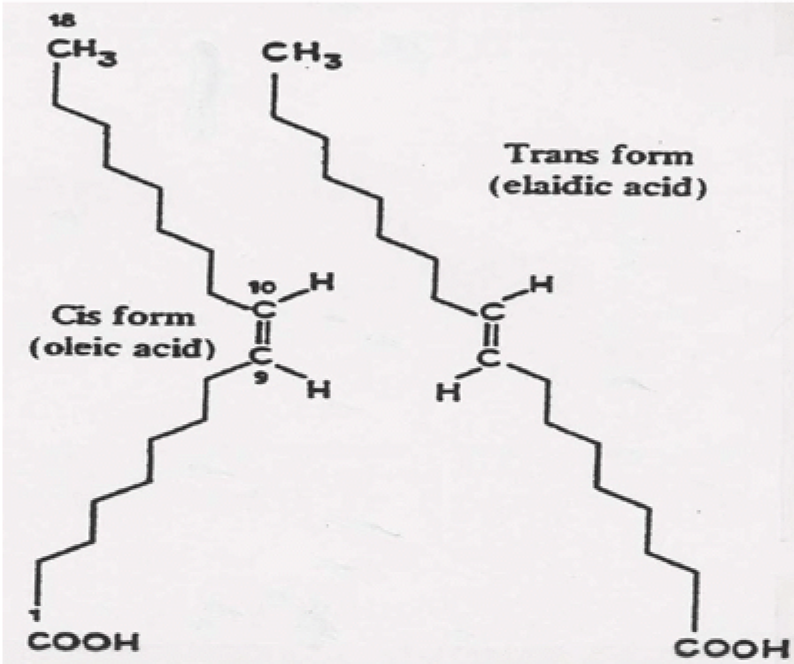




As was the case with saturated fatty acids, the schematic diagram above is not precisely correct because it does not show the correct angle of the carbon to carbon bonds which really is 109 degrees rather than 180 degrees. In the diagram below you see a geometrically correct diagram of oleic acid.



Notice in both diagrams of oleic acid that the hydrogen atoms occur on the same side of the double bond, rather than on opposite sides. When this configuration occurs, we must add another dimension to the naming scheme. Oleic acid now becomes 18:1n-9 *cis*, meaning that the two hydrogen atoms fall on the same side of the carbon to carbon double bond. Notice that the "*cis*" double bond causes a bend or "kink" in the carbon atom backbone. These kinks determine the shape of the fatty acid and become more and more important to the molecular function in our bodies as we consider polyunsaturated fatty acids. Before we get to polyunsaturated fatty acids, an additional factor in naming fatty acids must be considered. Oleic acid is the "normal" form of this monounsaturated fatty acid because it occurs most frequently and in the highest concentration in foods. However there are other variants of 18:1 called ISOMERS. Isomers are 2 molecules (fatty acids) with the same molecular weight but with differing structure. Fatty acids can have GEOMETRIC ISOMERS or POSITIONAL ISOMERS or both. Let us first consider geometric isomers ö a variant in which the hydrogen atoms occur on opposite sides of the carbon to carbon double bond. Below is a diagram of 18:1n-9, *trans*. Notice that compared to the normal, oleic acid, the hydrogen atoms are on the opposite (*TRANS*) side of the double bond. The common name for 18:1n-9, *trans* is *TRANS* ELAIDIC ACID. When people talk about "trans fatty acids" in margarine, shortening and processed foods, this is the specific fatty acid identified. Below is a schematic diagram of both oleic acid (18:1n-9, *cis*) and *trans* elaidic acid (18:1n-9, *trans*).



Please note that the incorporation of the "trans" double bond in 18:1 causes the normally "kinked" fatty acid to become straightened out similar to saturated fatty acids. This change in shape is the primary reason why a good fatty acid (oleic) becomes a bad fatty acid (*trans* elaidic) in its effect upon blood cholesterol levels.

The other kind of isomer that fatty acids can form is called a POSITIONAL ISOMER in which the "*cis"* double bond presents itself in a position other than the normal position along the carbon backbone. An example of this would be 18:1n-12, *cis* in which the double bond appears at the 12th carbon atom down from the omega (n) end of the molecule instead of the n-9 position that normally occurs in oleic acid. Finally, isomers of fatty acids can simultaneously contain both positional and geometric isomers such as 18:1n-11, *trans* which is called *TRANS* VACCENIC ACID. This is one of the few naturally occurring *trans* fatty acids and is present in the fats derived from ruminant mammals. Butter, cheese, milk and beef fat contain between 3-5 % trans vaccenic acid. However, unlike 18:1n-9 *trans* (*trans* elaidic acid), 18:1n-11, *trans* appears to be beneficial because in the body it is converted to another fatty acid called conjugated linoleic acid (CLA) which has anti-cancer and cardiovascular protective effects.

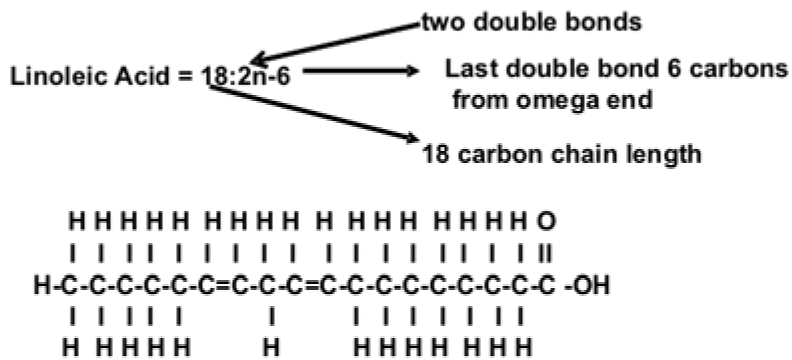
Polyunsaturated Fatty Acids

Polyunsaturated fatty acids contain two or more double bonds along their carbon backbones. Polyunsaturated fatty acids are classified into two biologically important subgroups: 1) OMEGA 6, and OMEGA 3 fatty acids. Below is a list of the common and numeric names for omega 6 and omega 3 polyunsaturated fatty acids that may occur in foods.

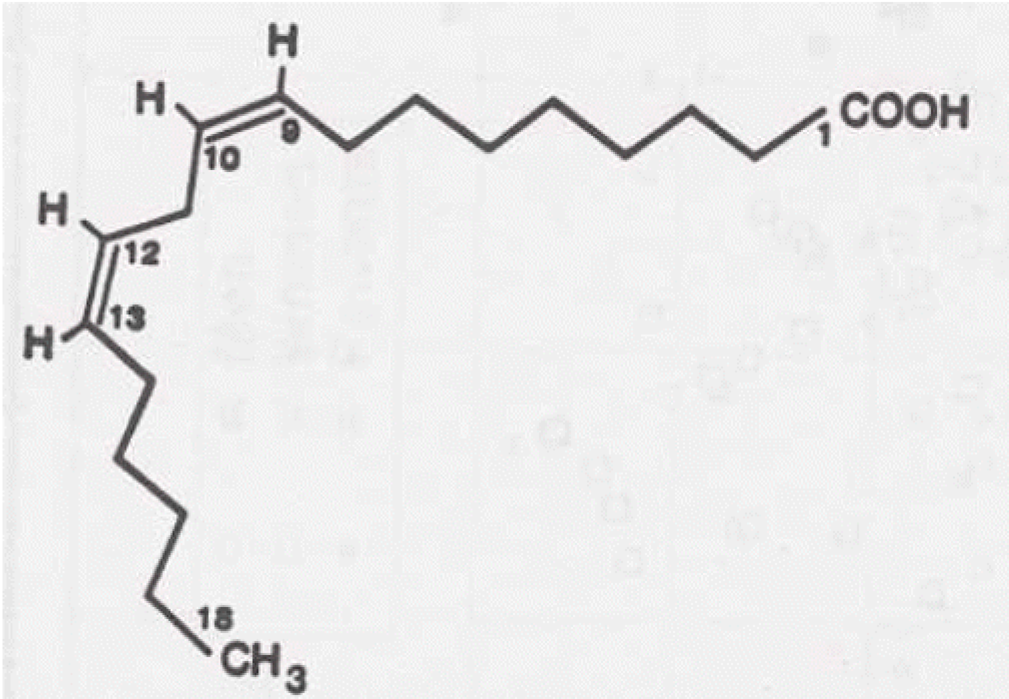
OMEGA 6 FAMILY	
Common Name	Numeric Name
Linoleic acid	18:2n-6
Gamma linolenic acid	18:3n-6
--	20:2n-6
Dihomo gamma linolenic acid (DHGLA)	20:3n-6
Arachidonic acid	20:4n-6
Docosatetraenoic acid	22:4n-6
--	22:5n-6

OMEGA 3 FAMILY	
Common Name	Numeric Name
Alpha linolenic acid (ALA)	18:3n-3
Parinaric acid	18:4n-3
	20:3n-3
Eicosatetraenoic acid	20:4n-3
Eicosapentaenoic acid (EPA)	20:5n-3
Docosapentaenoic acid (DPA)	22:5n3
Docosahexaenoic acid (DHA)	22:6n-3

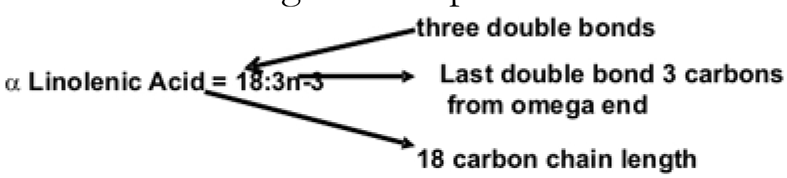
The numeric naming scheme for polyunsaturated fatty acids follows upon that for saturated and monounsaturated fatty acids. With OMEGA 6 polyunsaturated fatty acids, the last double bond (=) occurs 6 carbon atoms down from the omega or methyl end of the fatty acid, whereas with OMEGA 3 polyunsaturated fatty acids, the last double bond (=) occurs 3 carbon atoms down from the omega end of the fatty acid. In the case of linoleic acid (18:2n-6), there are 18 carbon atoms in the molecule, 2 double bonds (=), and the last double bond is located 6 carbon atoms down from the omega or methyl end of the fatty acid. Below is a schematic diagram of linoleic acid.



As was the case with saturated and monounsaturated fatty acids, the schematic diagram above is not precisely correct because it does not show the correct angle of the carbon to carbon bonds which really is 109 degrees rather than 180 degrees. In the diagram below you see a geometrically correct diagram of linoleic acid.



Let is now examine the structure of an omega 3 fatty acid, alpha linolenic acid or 18:3n-3. There are 18 carbon atoms in the molecule, 3 double bonds (=), and the last double bond is located 3 carbon atoms down from the omega or methyl end of the fatty acid. Below is a schematic diagram of alpha linolenic acid.

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  H H H  H H  H H H H  H  H H H  H H H H O
  I  I  I   I  I   I  I  I  I   I   I  I  I   I  I  I  I ll
H-C-C-C=C-C-C=C-C-C=C-C-C-C-C-C-C-C-C -OH
  I  I         I        I         I  I  I  I  I  I  I
  H  H         H        H         H H H H  H H H
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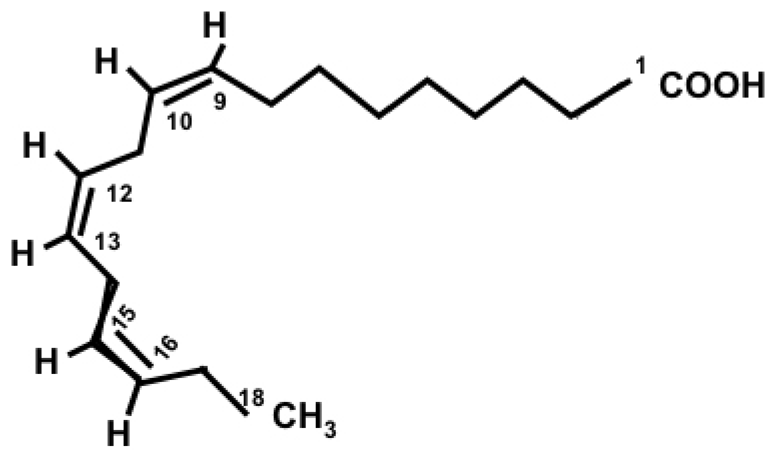
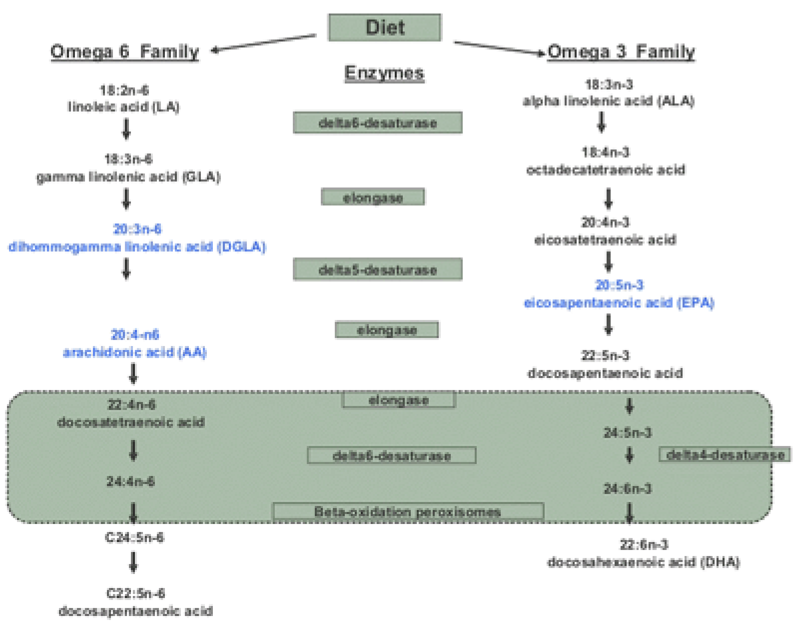
As was the case with saturated and monounsaturated fatty acids, the schematic diagram above is not precisely correct because it does not show the correct angle of the carbon to carbon bonds which really is 109 degrees rather than 180 degrees. In the diagram below you see a geometrically correct diagram of alpha linolenic acid.



Alpha linolenic acid (18:3n-3) is the so-called "parent" fatty acid for the omega 3 family of fatty acids because the liver can make other omega 3 fatty acids from it. Similarly, linoleic acid (18:2n-6) is the "parent" fatty acid for the synthesis of other omega 6 fatty acids in the liver.   Below is a diagram of how both parent fatty acids can be desaturated and chain elongated in the liver into longer chain polyunsaturated fatty acids.



The conversion of dietary 18 carbon polyunsaturated fatty acids (PUFA) to longer chain (≥ 20 carbon atoms in length) PUFA is an inefficient process.   Only about 6 % of ALA is converted to EPA and less still (3.8 %) is converted to DHA. Because omega 3 and omega 6 parent fatty acids must compete for the same enzymes of desaturation and elongation, a high dietary intake of omega 6 fatty acids (18:2n-6) can further reduce the conversion of ALA to EPA and DHA by 40 to 50 %.

The typical western diet is overloaded with omega 6 fatty acids and contains insufficient omega 3 fatty acids. The current ratio of omega 6 to omega 3 fatty acids in the U.S. diet is about 10:1 whereas in hunter-gatherer diets it is closer to 2:1. This dietary imbalance in fatty acids (excessive omega 6 and insufficient omega 3) is a fundamental underlying cause of many chronic diseases including cardiovascular disease, many cancers, most inflammatory diseases, and many psychological disturbances.

There are multiple physiological reasons why this laundry list of illnesses and diseases can be caused by or exacerbated from an imbalance in omega 6 and omega 3 fatty acids, but one of the most crucial stems from the synthesis of paracrine (nearby) hormones called eicosanoids. Eicosanoids are synthesized from three 20 carbon fatty acids (20:3n-6, 20:4n-6 and 20:5n-5) lying in cell membranes. Eicosanoids have multiple regulatory functions in the body including regulating the inflammatory response. Eicosanoids synthesized from 20:5n-3 (EPA) tends to be anti-inflammatory whereas eicosanoids derived from 20:4n-6 (arachidonic acid) may promote inflammation in certain tissues. Because of the imbalance in the (omega 6/omega 3) ratio in the typical western diet, a chronic state of low grade inflammation can exist which in turn may promote many health disorders and diseases.