

Cell Membrane Health: Your Door To Health

Original Internist, June, 2008 by Rachel Olivier

Biological cell membranes are fluid membranes as depicted by the fluid mosaic model of phospholipids and proteins. They possess amphipathic (polar and nonpolar) characteristics, which enables them to spontaneously form bilayers, with the hydrophilic portions facing the aqueous side, and the hydrophobic (water repelling) core on the inner side. As a chief component of these membranes, essential fatty acids play a major role in both membrane structure and function. As summarized by Mead, their actions fall into three major classes. The first class is depicted by their involvement in the "homeoviscous control of the membrane bilayer." In this capacity they serve to regulate intrinsic membrane enzymes and proteins, both of which are critical for the structural integrity of the membrane. Secondly, they are required as precursors to the eicosanoids, which includes various end products such as prostaglandins, leukotrienes, and thromboxanes, all of which profoundly influence cellular reactions. Finally, they serve to regulate the transport processes across the cell membrane. An additional critical function of essential fatty acids not mentioned by Mead is their action in the modulation of gene expression.'

As one of the classes of essential fatty acids, omega-3 (to -3) fatty acids serve a number of basic biological roles, including: their involvement in the structure and function of biological membranes; and their importance as both cellular signals and hormone precursors. They are also vital to the cellular metabolism, acting as an aide in the regulation of nutrient uptake and excretion. Diets deficient in essential fatty acids have the potential to result in enormous consequences, both on body metabolism and function. Additionally, it is currently estimated that the typical North American diet contains a much greater percentage of omega-6 fatty acids, outnumbering the intake of omega-3 fatty acids by a factor of twenty. Symptoms of fatty acid deficiency are numerous and comprise skin problems, including eczema, psoriasis, and dry skin, inflammatory arthritis, learning problems, attention deficit, irritability, melancholy, fatigue, frequent infections and an increased synthesis of triglycerides. Numerous studies have correlated [omega-3] fatty acid intake with beneficial attributes for a wide range of these physiological situations, and recent research has associated their intake with the modulation of gene expression.

The most active and beneficial derivatives of marine-derived [omega]-3 fatty acids are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Both the brain and nervous system are higher in DHA, as compared to the rest of the body. Low brain serotonin levels have been linked to low levels of DHA, resulting in an increased tendency towards despair, suicide, and violence. Additionally, based on observations in animals, it has been hypothesized that high levels of DHA in the brain may enhance neuronal survival. Low levels of [omega]-3 fatty acids have been associated with behavioral issues and learning problems in children with attention shortfalls, including behavior and learning problems. Seafood, cold-water fish in particular, is known to be an excellent source of [omega-3] fatty acids. Thus it is not surprising that seafood consumption during pregnancy was correlated to the child's verbal intelligence quotient (IQ), noting that low maternal seafood intake (<340g per week) increased the risk of children ranking in the lowest quartile of IQ scoring, compared to those mothers who consumed a higher quantity of seafood (> 340 g per week). In addition, low maternal seafood intake was correlated to suboptimal social development, with lower indices in social behavior, fine motor, communication, and social development scores.

A reduction in inflammatory markers, including C-reactive protein, IL-6, COX and lipoxygenase (LOX), has been correlated with a high intake of polyunsaturated fatty acids (PUFAs). Numerous studies have documented the beneficial effects of diets high in [omega]m-3 PUFAs. Consequently, an increased intake of [omega]-3 PUFAs has been associated with a reduction in cardiovascular events and other related complications, and in many populations the risk of cardiovascular illness has been inversely correlated with the dietary intake of [omega]-3 PUFAs. Conversely, a diet high in [omega]-6 EFAs, such as the Standard American Diet, results in the production of inflammatory prostaglandins, thromboxanes, leukotrienes, and other metabolites of arachidonic acid (AA; 20:5n-3), which, in turn, contributes to the formation of thrombi and atheromas, allergic and inflammatory consequences, and cellular proliferation. EPA-derived eicosanoids have established effectiveness in blocking the production of series-2 prostaglandins, for example PGE2 and PGF2-a, which when elevated ensues in an anti-inflammatory response. Additionally, an increase in [omega]-3 fatty acids has demonstrated a diminishing effect on the level of proinflammatory markers, including IL-6, high density lipoprotein, TNF-a and C-reactive protein, along with a corresponding elevation in anti-inflammatory markers, including soluble IL-6 receptor and IL-10. Accordingly, a fitting dietary change for cardiovascular health benefits is to emphasize an increase in the dietary amounts of [omega]-3 fatty acids, including the fish oil constituents EPA and DHA, while simultaneously decreasing the dietary content [omega]-6 fatty acids. Conservative estimates indicate that to balance this ratio, there would have to be a four-fold increase in fish consumption. Alternately, supplemental forms of [omega]-3 fatty acids could be incorporated into the diet to achieve adequate EFA intake.

In addition to its benefit in inflammation, [omeg]-3 fatty acids have also demonstrated beneficial therapeutical effects for persons with symptoms of depression. It is well known that the essential fatty acids play a central part in both the development and function of the central nervous system. Epidemiological evidence has correlated the intake of fish/seafood with a lower occurrence of these symptoms. In addition to general melancholy symptoms, a high intake of fish/seafood has also been correlated to protection against symptoms of melancholy following pregnancy, unbalanced/mood instability and seasonal sadness. A random sampling study confirmed the benefits of frequent fish consumption, indicating that it was significantly associated with a decreased frequency of melancholy and suicidal contemplation. A cross-sectional study also established a correlation between fish consumption and mental health, as a result of a higher self-reported mental health status. In a separate study, depressive symptoms were correlated to a higher [omega]-6: [omega]-3 ratio, which as indicated above enhances the production of pro-inflammatory cytokines, confirmed by elevated levels of TNF-[alpha] and IL-6.

References:

- (1.) Singer S J, Nicolson G L. The fluid mosaic model of the structure of cell membranes. *Science* 1972 175:720-31.
- (2.) Mead JF. The non-eicosanoid functions of the essential fatty acids. *Journal of Lipid Research* 1984 Volume 25:1517-1521.
- (3.) Clarke SD, Jump DB. Dietary polyunsaturated fatty acid regulation of gene transcription. *Annu Rev Nutr.* 1994;14:83-98. Review.
- (4.) Vasquez A. Integrative Orthopedics Concepts, Algorithms, and Therapeutics. The art of creating wellness while effectively managing acute and chronic musculoskeletal disorders. Natural Health Consulting Corporation. 2004. p 420.

- (5.) Logan AC. Omega-3 fatty acids and major depression: A primer for the mental health professional. *Lipids in Health and Disease* 2004. 3:25.
- (6.) Siguel E. A new relationship between polyunsaturated fatty acids and total/HDL cholesterol. *Lipids*. 1996;31:S51-S56.
- (7.) Siscovick DS, Raghunathan TE, King I, Weinmann S, Wicklund KG, Albright J, Bovbjerg V, Arbogast P, Smith H, Kushi LH, Cobb LA, Copass MK, Psaty BM, Lemaitre R, Retzlaff B, Childs M, Knopp RH. Dietary intake and cell membrane levels of long-chain n-3 polyunsaturated fatty acids and the risk of primary cardiac arrest. *JAMA*. 1995;274:1363-1367.
- (8.) Das UN. Essential fatty acids in health and disease. *Assoc Physicians India*. 1999 Sep;47(9):906-11
- (9.) Bordoni A, Astolfi A, Morandi L, Pession A, Danesi F, Di Nunzio M, Franzoni M, Biagi P, Pession A. N-3 PU-FAs modulate global gene expression profile in cultured rat cardiomyocytes. Implications in cardiac hypertrophy and heart failure. *FEBS Letter*. 2007 Mar 6;581(5):923-9. Epub 2007 Feb 6.
- (10.) Akbar M, Calderon F, Wen Z, Kim HY. Docosahexaenoic acid: A positive modulator of Akt signaling in neuronal survival. *PNAS* 2005 102(31): 10858-10863.
- (11.) <http://news.uns.purdue.edu/html4ever/1996/9606.Burgess.html>
- (12.) Hibbeln, JR, Davis, JM, Steer, C, Emmett P, Rogers I, Williams C, Golding J. Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study. *Lancet*. 2007 369;9561: 578-85.
- (13.) De Calerina, R, Madonna, R, Massaro, M. Effects of omega-3 fatty acids on cytokines and adhesion molecules. *Curr Atheroscler Rep*. 2004Nov;6(6):485-91.
- (14.) Simopoulos AP, Essential fatty acids in health and chronic disease. *Am J Clin Nutr*. 1999 Sep;70(3 Suppl):560S-569S.
- (15.) Ferrucci L, Cherubini A, Bandinelli S, Bartali B, Corsi A, Lauretani F, Martin A, Andres-Lacueva C, Senin U, Guralnik JM. Relationship of Plasma Polyunsaturated Fatty Acids to Circulating Inflammatory Markers. *J Clin. Endocrin Metab*. 2006 91(2):439-446.
- (16.) Kris-Etherton PM, Taylor DS, Yu-Poth S, Huth P, Moriarty K, Fishell V, Hargrove R, Zhao G and Etherton TD. Polyunsaturated fatty acids in the food chain in the United States. *Am J Clin Nutr* 2000; 71 (suppl):179S-88S.
- (17.) Hibbeln JR: Fish consumption and major depression. *Lancet* 1998, 351:1213.
- (18.) Hibbeln JR: Seafood consumption, the DHA content of mothers' milk and prevalence rates of postpartum depression: a cross-national, ecological analysis. *J Affect Disord* 2002, 69:15-29.
- (19.) Noaghiul S, Hibbeln JR: Cross-national comparisons of seafood consumption and rates of bipolar disorders. *Am J Psychiatry* 2003, 160:2222-2227.
- (20.) Cott J, Hibbeln JR: Lack of seasonal mood change in Icelanders. *Am J Psychiatry* 2001, 158:328.
- (21.) Tanskanen A, Hibbeln JR, Tuomilehto J, Uutela A, Haukkala A, Viinamaki H, Lehtonen J, Vartiainen E: Fish consumption and depressive symptoms in the general population in Finland. *Psychiatr Serv*, 2001,52:529-531.
- (22.) Silvers KM, Scott KM: Fish consumption and self-reported physical and mental health status. *Public Health Nutr* 2002, 5:427-431.
- (23.) Kiecolt-Glaser JK, Belury MA, Porter K, Beversdorf DO, Lemeshow S, Glaser R. Depressive symptoms, omega-6:omega-3 fatty acids, and inflammation in older adults. *Psychosom Med*. 2007 Apr;69(3):217-24.
- (24.) Harris WS: n-3 fatty acids and human lipoprotein metabolism: an update. *Lipids* 1999 34 (Suppl.):S257-S258.

- (25.) Krauss RM, Eckel RH, Howard B, Appel LJ, Daniels SR, Deckelbaum RJ, Erdman JW Jr, Kris-Etherton P, Goldberg IJ, Kotchen TA, Lichtenstein AH, Mitchell WE, Mullis R, Robinson K, Wylie-Rosett J, St Jeor S, Suttie J, Tribble DL, Bazzarre TL. AHA dietary guidelines: revision 2000: a statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *Circulation* 2000 102:2284-2299.
- (26.) De Caterina R, Madonna R, Bertolotto A, Schmidt EB. n-3 Fatty Acids in the Treatment of Diabetic Patients. *Diabetes Care* 2007 30:1012-1026.
- (27.) <http://lpi.oregonstate.edu>.
- (28.) Savelieva I, Camm J, Statins and Polyunsaturated Fatty Acids for Treatment of Atrial Fibrillation. *Nature Clin Practice Cardiovasc Med* 2008 5 (1):30-41.
- (29.) Wolf PA, Dawber TR, Thomas HE, Kannel WB. Epidemiologic assessment of chronic atrial fibrillation and risk of stroke: the Framingham study. *Neurology* 1978 28 (10): 973-7.
- (30.) Simopoulos, AP, Leaf A, Salem, N. Workshop on the Essentiality of and Recommended Dietary Intakes (RDI) for Omega-6 and Omega-3 Fatty Acids. Washington. DC. April 1999.

Rachel Oliviver "[Cell membrane health your door to health](#)". Original Internist. FindArticles.com. 16 Nov, 2009.