Lecture I: Nomenclature, Metabolism, Omega-3 Tissue Balance in Dogs and Cats, Uniqueness of Cats, Puppy Development

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Introduction to the fatty acids

The various cells of the animal body including neutrophils and various tissues cells perform both structural and functional roles in the animal body

The cell membranes of these cells contain proteins and long chain fatty acids including the polyunsaturated fatty acids that impart important structural and functional mediators of cell functions.

The food supply contains both facilitative and functions fats that facilitate the digestion and absorption of the fat soluble vitamins. Functional fats include the long chain polyunsaturated fatty acids (PUFA) containing two or more double bonds. These fats are dietary essentials and serve as precursors of important mediators of physiologic function.

Functional fats are the omega-6 (n-6) and omega-3 (n-3) series fatty acids. The omega or n-designation refers to the position of the first double bond from the methyl end of the long hydrocarbon chain molecule. These are considered dietary essentials because neither type can be synthesized by the animal body from precursors. They must be supplied in diets.

Terrestrial animals and plants, including seed oils are generally abundant in omega-6 fatty acids as are many pet foods that contain these types of ingredients. These include linoleic (18:2n-6) and, from food animals, arachidonic (20:4n-6) acids. Marine sources contain relatively increased amounts of the omega-3 types. It should be noted that some terrestrial plants such as flax and canola (rape) also contain a type of omega-3 but this component is a shorter chain length molecule (18:3n-3) compared with the marine types.

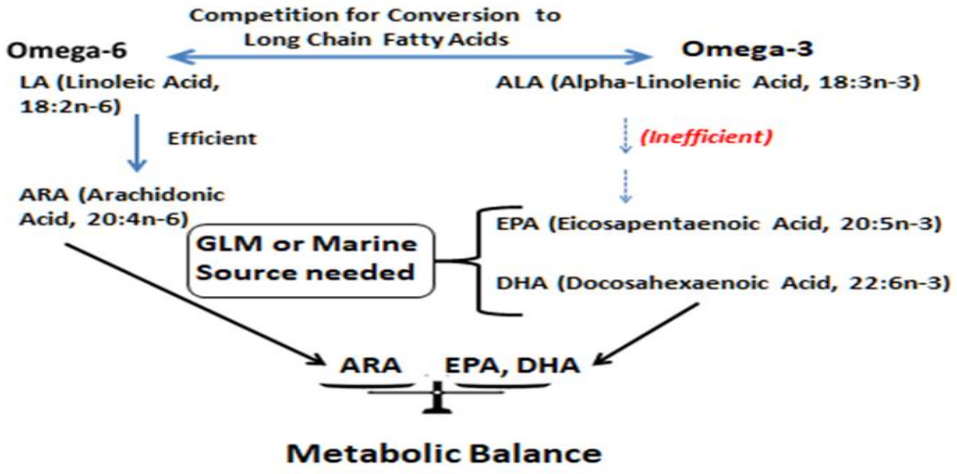
In recent years more pet food formulations now contain varying amounts and types of omega-3 due to their perceived health benefits. In some situations, however, supplementation may be preferred.

Omega Fatty Acid Metabolic Balance

The omega polyunsaturated fatty acids (PUFA) of most interest are arachidonic (ARA, 20:4n-6), eicosapentaenoic (EPA, 20:5n-3) and docosahexaenoic (DHA, 22:6n-3). Other types may also be important. Although plant sources of omega-6 and omega-3 fatty acids are present in the food supply, they must typically be metabolically converted to longer chain derivatives such as arachidonic (ARA, 20:4n-6), eicosapentaenoic (EPA, omega-3,

and docosahexaenoic (DHA, omega-3) before they become physiologically active. The physiologic balance between both omega-3 and omega-6 types is important because they compete for the same enzyme systems for their metabolism. Conversion of omega-6 fatty acids to the long chain forms is more efficient than the omega-3s; thus when omega-6s are abundant in the diet as in many pat foods, omega-3s may become unbalanced in tissues (Figure 1). Providing a dietary supply of omega-3 directly restores this balance (Figure 1).

Figure 1: Metabolic Conversions of Essential Fatty Acids needed to achieve Metabolic Balance in Tissues



Synthesis of cellular mediators of physiologic function from long chain PUFA substrates.

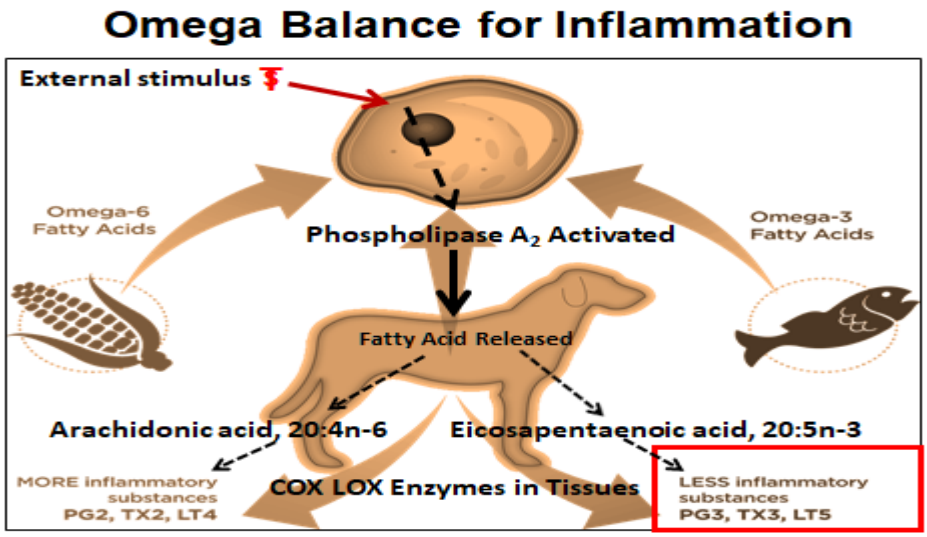
Long chain PUFA, when incorporated into cell membranes, convert into functional regulatory molecules as substrates for the synthesis of numerous eicosanoids that are powerful mediators of cell function. Given that various cell types have diverse functions, these eicosanoids have a wide and unique range of action depending on the cell type that is enriched in the particular omega-6 or omega-3 fatty acid precursor.

The formation of these mediators begins with some stimulus to the cell such as a skin scrape or other tissue damage but also from potentially more serious conditions. Following such an event, a membrane enzyme called phospholipase A_2 enzyme is activated. This enzyme acts on the membrane phospholipid typically

containing the long chain PUFA. If the cell is enriched in arachidonic acid (ARA, 20:4n-6) inflammation may occur. If the cell is relatively enriched in enriched in the eicosapentaenoic acid (EPA, 20:5n-3) a less inflammatory is achieved.

It should be noted that all of the eicosanoid regulatory molecules tend to act locally and are short-lived being degraded rapidly and not circulated in the bloodstream. Consequently it is necessary for omega-3 fats to become a regular part of a healthy diet in order to provide cellular health and general well-being.

Figure 2: The inflammatory cascade of events involving cell membrane phospholipids
enriched in either omega-6 or omega-3 fatty acids



Uniqueness of Cats

Polyunsaturated fats (PUFA) are especially important in cats because they are at risk for overall PUFA deficiencies. Dogs can make arachidonic acid omega-6 from linoleic acid omega-6 but cats cannot. Also, cats cannot make eicosapentaenoic acid (EPA omega-3) from alpha-linoleic acid (ALA onega-3). Thus, they need both long chain omega-6 and omega-3 in their diets. Dogs, by comparison only need to have long chain omega3 provided. The reason for this is a low activity of the Δ-6 desaturase enzyme in cats that converts omega-6 (LA to AA) and omega-3 (ALA to EPA/DHA). This enzyme is active in dogs.

Omega-3 in Puppy Development; Vision, Cognition and Learning

Both AA and DHA are critical for puppy development. Structural evidence showed increased retinal DHA when omega-3 was fed. Functional evidence has shown that when high omega-3 was fed during gestation, lactation, and weaning, plasma and milk omega-3 was increased. In addition, puppies from dogs fed long chain omega-3 during gestation, , improved visual performance (electroretinograms, ERG), response to light more quickly, and increased visual function in dim light. Preformed long chain DHA omega-3 was better than shorter chain ALA in these studies. Another study also found improvements in ERG response when puppies were first fed omega-3 at weaning. In addition this study also evaluated cognition and learning abilities. In this study, puppies demonstrated fewer t-maze errors, improved cognition and trainability as observed with better reversal task learning, visual contrast discrimination, early psychomotor responses, and better side-to-side navigation through an obstacle maze. Taken together it has been concluded that DHA should be considered an conditionally essential nutrient for puppy development and that a 0.2% dry matter diet provides these improvements compared to a typical diet.