THE CANINE DIET:

A LOOK INTO THE EVOLUTION AND CURRENT STATE OF DIET IN THE DOG

By

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Abstract:

Nutrition and diet are both key elements to proper management of domestic dogs. Nutrition can play roles both in the development and cause of disease as well as in the management and treatment of disease. Currently relevant issues in regards to this include obesity in dogs, as well as diseases such as diabetes mellitus, pancreatitis and food allergies. Deciding what to feed the dog is therefore important, but it can often be a daunting task as there are so many options available today. Here, a review of the history of nutrition in the dog and of present day feeding options is presented.

Introduction

Dogs have shared a unique connection with mankind for thousands of years, famously becoming known as man's best friend. Throughout our history together and the building of this unique relationship many of our interactions with dogs have been based around food. People often use food to reward, train and in some cases form a bond with their dogs. Nutrition and diet in the dog is therefore an important part of ownership and care.

When I began writing this paper, my family had recently added a new four legged member to the group, Rufus. Amidst the excitement of having a new puppy in the house my parents were wondering what kind of food he should be getting in order to lead a long, happy, and healthy life. Thinking that I must be learning something while away at college my parents asked me, what's the best dog food? I was stumped. My previous dog had faithfully subsisted on a steady diet of Old Roy for all of his fifteen years, so I had no reason to pay attention to the explosion of new varieties of dog foods that now existed on the market. When walking into a pet store now you are confronted with aisles of choices from dry food, wet canned food, fresh refrigerated food, diets for young dogs, diets for old dogs, diets for certain conditions, grain free diets, high protein diets and so on. How is an owner to choose? Therefore, I set out to learn more about diet and nutrition in the dog. My effort to learn more began by studying the history of the dogs and their ancestors. From learning about the similarities and differences between ancient and modern dogs, I moved on to studying the dog food market today and finally how nutrition impacts the overall health of the animal.

The History and Evolution of the Dog

To begin with, where is it that dogs fit in within the natural world? Dogs belong to the family Canidae. Other members include wolves, coyotes, jackals and foxes. As a group this family of animals has been on this Earth for more than forty million years (Wang, VIII). All canids can also be classed as members of a larger subset of animals, the carnivores. Carnivores are a group of animals that, among other similarities, all "possess a common arrangement of teeth, the last upper premolar and lower first molar have bladelike enamel crowns that function together as shears" (Wang, 1). These shearing teeth are termed carnassials, and are an important adaptation to the process of cutting meat (Wang, 1). Furthermore, in mammalian carnivores the toes and claws tend to be "powerful and distinct from one another, thereby offering a firm purchase on the ground" (McLoughlin, 14). Both of these characteristics contribute to the defining attribute of carnivores; they are animals that predominately consume meat.

Among carnivores, canids have the most conservative or least modified teeth over time. Canids have a bilateral complement of teeth divided into three upper and lower incisors, one upper and lower canine, four upper and lower premolars, two to three upper molars and three lower molars (Wang, 70). With a few exceptions all other modern families of carnivores have evolved to have fewer teeth over time (Wang, 70). Such a reduction in the number of teeth usually is an indication of a specialized diet trending towards hypercarnivory (Wang, 71). Hypercarnivory is an attribute of animals that have elongated the shearing blade of the carnassial teeth at the expense of the grinding part of the dentition, the molars (Wang, 75). The adaptation of hypercarnivory is believed to be related to a diet that is made up almost exclusively of meat (Wang, 75). Members of the cat family would be good examples of hypercarnivores. The other extreme end of the scale would be a hypocarnivore, this refers to an animal that has shortened the shearing blade of the carnassial teeth and enlarged the molars (Wang, 75). Canids fall in between these two categories and are classified as mesocarnivores (Wang, 75). Therefore, the canids, including the dog, have evolved in a way that allows for the animal to consume a much wider variety of the foods that are available from the world (McLoughlin, 27). This ability to partake of a greater variety of food options “offers a tremendous advantage to its practitioners,” in particular the “canids are much less vulnerable than the cat like [animals] to changes in the population density of their prey species” (McLoughlin, 27).

The first carnivores to inhabit the Earth appeared around 55 million years ago. Five million years after their arrival the carnivores split into the Aeluroidae, or catlike ones, and the Canoidea, or dog like ones (McLoughlin, 25). By the late Eocene period, or around 40 million years ago, the first true member of the canids had evolved (McLoughlin, 40). These first canids were found to have lived in North America (Hare, 20). Examples of these early canids include *Mesocyan*, an animal that existed 30 million years ago (McLoughlin, 40). *Mesocyan* was a long bodied and short limbed, coyote sized animal termed the “half dog” (McLoughlin, 41). *Canis ferox* is a more recent ancestor having lived six million years ago (Hare, 20). *Canis ferox* was the size of a small coyote with a more robust build and a large head (Hare, 20). After these early ancestors, between 1.7 and 1.9 million years ago, the first wolf was seen in the fossil record, *Canis etruscus* or the Etruscan wolf (Hare, 21). This animal is the most likely ancestor to modern wolves (Hare, 21). Around the same time period that *Canis etruscus* was first appearing the Bering land bridge was formed between North America and Asia. As a result these early canids were then able to cross over from North America into Asia and from there spread all over the continent.

From these early beginnings wild wolves eventually gave rise to their relative the domestic dog. Archeological evidence suggests that dogs began to differentiate from wolves somewhere between twelve and forty thousand years ago (Hare, 17). Dogs differ both morphologically and behaviorally from wolves. Dogs tend to be less aggressive and display “altered social cognition abilities,” they also show a reduction in the size of the teeth, skull and the brain (Axelsson). Axelsson et al. recently published research concerning an analysis of the genetic differences between wolves and dogs. In the course of their research the authors found 36 genomic regions that most likely represent targets for selection to act upon during the course of domestication (Axelsson). A significant number of these regions were related to brain function and could explain the behavioral differences that are seen in wolves and domestic dogs (Axelsson). However, ten of these genomic regions were found to be involved in starch digestion and fat metabolism (Axelsson). It was found that adaptations to the genes encoding the enzymes AMY2B, MGAM, and SGLT1 would have provided the ancestors of the dog with an increased ability to both break down and absorb foods rich in starch. This would have been in contrast to their wolf cousins, which maintained a mostly carnivorous diet (Axelsson).

Domestication

The mechanism of domestication can be defined as “an evolutionary process resulting from changes in selection pressures on species or a population created by an artificial environment” (Fox, 4). The dog was most likely the first species that was domesticated by human beings and represents the most successful domestication of a carnivore by man. There have been only about fourteen other animals that have been successfully domesticated by humans (Wang, 154). Most of these animals were originally from Eurasia and all were herbivores (Wang, 154). Dog domestication as an event most probably occurred towards the end of the last ice age, when humans still depended on hunting, gathering and foraging for survival (Serpell, 10). This would have been at least 10,000 years ago (Axelsson). In looking at how and where dog domestication occurred there is still much controversy. Some authors have suggested that domestication began when humans adopted wolf puppies or when humans and wolves began to hunt together. Others have suggested that the dog was first raised with humans as a food source. This last, however, seems the least likely as dogs “consume more humanly edible food than they produce” (Wang, 156). There exists another alternative as well; the idea that dogs domesticated themselves. This is a scenario discussed by Hare and Woods in their book *The Genius of Dogs.*

Hare and Woods begin by explaining that as human populations grew and spread a new and abundant food source was created, garbage (Hare, 89). Wolves, who previously would have tended to try and avoid humans, would have become more attracted to human settlements when there were piles of bones, vegetable scraps and rotting meat nearby (Hare, 89). The individual wolves that were more willing to approach these garbage piles and that were not overly aggressive to the humans would have had a distinct advantage over other more aggressive wolves living in close proximity to human settlements. These calmer, less aggressive individuals would have then passed on the genes that gave them this more relaxed personality to their offspring (Hare, 89). Thus, through the generations a subset of the wolves would have displayed marked behavioral changes leading to domesticated behavior, without any direct breeding or selection by humans.

A domestication experiment done by the Russian scientist Belyaev on foxes further suggests that selection based upon behavior also leads to the physical changes we associate with domestic dogs. Belyaev's experiment involved a breeding program where only the friendliest foxes were bred; those animals that were more aggressive towards humans were only bred to serve as a control group (Hare, 74). After a relatively short time, Belyaev found a significant difference between the two populations. The control group still showed fear and aggression while the experimental foxes were much more comfortable around people, and even craved attention. There were also physical changes in the animals. Some developed floppy ears, curled tails, and different coat colors and patterns (Hare, 78). These physical differences are some of the same trademark differences between domesticated dogs and their wild ancestors. The results of this experiment suggest that simply selecting for behavioral differences in animals can result in the drastic differences we see both behaviorally and physically between wild and domestic canines.

Modern Dogs

If we fast forward from the first domestic dogs, through years and years of selective breeding and partnerships with humans we reach the modern domestic dog. Today the family Canidae is divided into thirty eight different species. These include the domestic dog, *Canis familiaris*, and close relatives such as jackals, *Canis aureus*, *Canis mesomelas* and *Canis adustus*, as well as coyotes, *Canis latrans*, and wolves, *Canis lupus* (Bradshaw, 1927S). The domestic dog itself displays a tremendous amount of variation in characteristics such as coat color, size and shape, with breeds ranging from the Chihuahua and the Pomeranian to the Great

Dane and the German shepherd. In terms of diet and nutrition the domestic dog is actually classified as an omnivore and behaves as an opportunistic feeder. *Canis familiaris* has the ability to “consume and derive nourishment from a variety of foods of both animal and vegetable origin” (Hilton, 855).The dog’s close relative the coyote is also classed as an omnivore, subsisting on fruit and other plant materials when prey is hard to find (Bradshaw, 1928S). Furthermore, the dog is characterized by having a “relatively unspecialized dentition and a taste system that is rather insensitive to salt” (Bradshaw, 1927S). As our modern dogs no longer hunt for their food, their selection of food is predominately based upon its availability as well as its appearance, odor, flavor, and texture. There are still traces of the wild ancestors in the dog however. Some modern dogs can have a reputation for consuming their food extremely quickly. This is potentially a remnant of competitive pack behavior, which could lead to obesity if not properly monitored (Bradshaw, 1927S).

Diet in the Dog

Any discussion of diet in an animal must first begin with an overview of some of the basic concepts of nutrition. A cornerstone of nutrition is the idea of an energy balance. An energy balance is reached when “energy expenditure is equal to energy intake, resulting in minimal changes in the body’s store of energy” (Case). The energy intake of an animal can be affected by a variety of different factors including the availability of food, the timing and size of meals, the composition and texture of available food, any changes in plasma concentrations of specific nutrients, hormones and so on (Case). Energy expenditure will be affected by activity level, pregnancy and other forms of work that the animal is engaged in. Formulating a diet for any animal will involve taking into account the energy expenditure and energy intake of the animal and whether or not the individual needs to be maintaining their weight, losing some weight or gaining weight.

The energy intake of the dog will come from some formulation of certain core nutrients. For the dog, the core nutrients that he must be provided with, or be able to obtain, include carbohydrates, protein, lipids, and vitamins and minerals. We will start with a discussion of carbohydrates. Carbohydrates are a source of glucose for the animal. Every single animal has a metabolic requirement for glucose (Case). However, not every single animal has a need to acquire glucose from their diet. Gluconeogenic pathways exist and function in organs such as the liver which allow for glucose to be synthesized from other precursors such as propionic acid, lactic acid, and some amino acids (Case). The dog is an example of an animal that is capable of meeting its glucose requirements through these gluconeogenic pathways, as long as other nutrients, specifically fat and protein, are provided in sufficient amounts (Case). Therefore, while glucose is essential to the dog, digestible carbohydrates are not necessarily a required component in the diet (Case).

In one study done by Dale R. Romsos and colleagues, dogs were fed diets that varied in the amount of digestible carbohydrates present. It was found that dogs fed the carbohydrate free diet gained just as much weight as those fed diets that contained carbohydrates (Romsos). Therefore, it was concluded that “many animals, including the dog, do not require any more dietary carbohydrate to maintain a normal growth rate than that supplied as glycerol in fat” (Romsos). This is not to say that carbohydrates are bad for dogs either. Both dogs and cats are able to “efficiently digest starch,” which “provides an economical and digestible energy source”

(Case). Starch is also important from a production standpoint as it is essential to the extrusion process used in the manufacture of most dog foods (Case).

A second critical nutrient in a dog's diet is fat. Fats, or triglycerides, are made up of a glycerol molecule with three fatty acids attached. Triglycerides are differentiated based upon the type of fatty acids that are bonded to the glycerol backbone. The fatty acids can be saturated, monounsaturated or polyunsaturated as well as long chain, short chain or medium chain fatty acids (Case). A medium chain triglyceride would be one that primarily contains fatty acids that are somewhere between eight and ten carbon atoms in length. Medium chain triglycerides (MCTs) are considered to be important in human diets because it has been shown that these molecules are rapidly hydrolyzed and absorbed by the human GI tract (Case). Because of these findings MCTs have been suggested as a possible form of dietary treatment for dogs with digestive disorders that affect normal fat digestion and absorption (Case). However, this has not been studied significantly, and others have reported a decrease in palatability and food intake when the level of MCTs is increased (Case). Another significant discussion with fats in the diet is the presence of trans double bonds in unsaturated fatty acids. In humans, trans fatty acids can have significant negative impacts on lipoprotein metabolism (Case). Whether or not trans fats have a similar impact on dogs has, again, not been studied significantly (Case). Fat is an important part of any dog's diet because it provides a significant amount of energy, more than twice the metabolizable energy per unit weight of either protein or carbohydrate (Case). Fat is secondly a source of necessary fatty acids, in particular omega-6 and omega-3 fatty acids (Case).

The third major nutrient in the diet is protein. Protein is made up of different amino acids linked together through covalent peptide bonds. The amino acids themselves are important in that they contain a significant amount of nitrogen. In order for a dog to maintain a regular body weight or to maintain growth it requires a regular supply of protein (Case). However, while the body does require protein or amino acids, at the cellular level it does not matter whether the amino acids used by the cells are supplied through the diet, or synthesized by the body (Case). Thus, it would be more correct to state that the body has a requirement for amino acids that it cannot synthesize itself, as well as for nitrogen an essential component for synthesizing amino acids (Case). There are ten essential amino acids that are recognized for the dog, meaning there are ten amino acids that the dog cannot synthesize and must be provided in the diet (Steiff). The Association of American Feed Control Officials (AAFCO) recommends that the minimum protein content of food on a dry matter basis is 18% ME for adult maintenance (Steiff).

Finally, the dog also has a requirement for certain vitamins and minerals. Two important minerals in the dog's diet are calcium and phosphorus. Calcium has two main function in the body; helping to maintain the structure of bone and teeth and its use as a cellular messenger (Steiff). Phosphorus also plays a role in the maintenance of the bone as well as being a crucial component of nucleic acids, and high energy compounds such as ATP and phospholipids (Steiff). It is recommended that an adult maintenance dog receive 0.6% dry matter as calcium and 0.5% dry matter as phosphorus (Steiff). The balance between these two minerals is very important. In all meat diets or diets made up predominately of meat problems can occur because of an imbalance between these two minerals. Meat is rich in phosphorus and low in calcium, thus an all meat diet can create a calcium deficiency which in turn can lead to conditions such as rickets and osteomalacia (Steiff).

Dog Foods

As was discussed earlier, dogs were first domesticated around 10,000 years ago, when humans still relied on hunting and gathering for sustenance. However, it was also around this time that the Neolitihic Agriculture Revolution occurred and humans began to move from a lifestyle based on hunting and gathering to a system based more on agriculture. As a result the human diet would have changed significantly. Dogs would have felt this change as well as they began to socialize with and depend on humans for their food source. From these early times, humans have continued to change and develop and our diet has become increasingly more based on grains, and in the later centuries, processed foods. Dogs and their diets have likewise followed suit.

Prior to the 1800's there were no commercial pet foods available to owners. Instead they relied on scraps and homemade meals. The *Sportman's Dictionary* from 1782 describes one diet that was suggested for the feeding of hunting dogs:

"In regard to their food, carrion is by no means proper for them. It must hurt their sense of smelling on which the excellence of these dogs greatly depends. Barley meal, the dross of wheat flour or both mixed together, with broth or skimmed milk is very proper food. For change, a small quantity of greaves from which the tallow is pressed by the chandlers, mixed with their flour; or sheep's feet well baked or boiled, are a very good diet, and when you indulge them with flesh it should always be boiled."

The first commercial dog food that was produced and sold was actually a dog biscuit (Case). This particular biscuit was manufactured starting in 1860 by an individual named James Spratt in England (Case). He was quickly followed by the F.H. Bennett Biscuit Company in the

1900's when they began producing Maltoid biscuits (Case). These later became the still popular treat Milk Bones (Case). Canned dog food was first introduced to the market in the year 1922 (Case). One of the most significant advancements in the history of the pet food industry was the development of the process of extrusion in the production of pet foods. This technique was first used to prepare dog foods in the 1950's (Case). The process of extrusion involves first mixing all of the different ingredients together and then rapidly cooking the mixture while forcing it through an extruder (Case). The benefits of this process include "achieving a desired physical form, inactivation of anti-nutritional factors, increase of shelf life, increased digestibility of nutrients and enhanced palatability" (Lankhorst). Undesirable side effects of this process may include loss of vitamins, destruction and reduction of the available amino acids and oxidation of lipids (Lankhorst). Not unexpectedly, this process thus has an impact on the nutritional value of the food (Lankhorst). C. Lankhorst and colleagues performed a study on the effect extrusion has on the nutritional value of canine diets. It was found that protein digestibility was not affected by different extrusion conditions; extrusion did have an effect on the SGD of the diet, or the starch gelatinization degree (Lankhorst). The extrusion process "gelatinizes" the starch, thus making it more digestible (Lankhorst). This result may indicate that postprandial glucose and insulin response in dogs may be affected by different extrusion methods (Lankhorst).

From its beginning in the early 1900's the pet food industry has only continued to grow. In the year 1958 the total pet food sales in the United States were estimated to be around 350 million dollars (Case). By the year 1996 total pet food sales had increased to 12 billion dollars (Case).More recently dog and cat food sales have continued to expand from $11.9 billion in 2000 to $19 billion in 2012 ("US Pet Food Trends"). Between the years 2000 and 2007 the US market for pet foods saw the introduction of a wide variety of new types of foods. These different products included diets formulated specifically for different life stages of the animal, activity levels and for different health conditions (Case). Finally, in the year 2013, the market was significantly focused on premium and super-premium dog foods. The company Hill reformulated their Science Diet dog food as a “natural product”, Wal-Mart added Pure Balance, which is their first natural pet food brand, and Nestle Purina added Purina One Beyond (“Pet Food in the US”). In 2013 there were also significant trends such as grain free, meat first and the use of human grade products in pet foods (“Pet Food in the US”). If you were to examine the different dog foods available at most large pet supply chains or grocery stores you might have a list comparable to the data in tables 1-3. The dog foods represented here nicely show the major shift dog foods have taken towards natural foods, meat first diets and premium quality foods as the majority of them have some kind of meat as the first ingredient rather than corn or other starches. Furthermore, the foods listed here also demonstrate the shift away from the use of by products and ingredients such as chicken by products as only two dry foods list this as the primary ingredient. This is not to say they are not present in other foods, just not as the primary ingredient. Finally, a large portion of the foods also appeal to the natural trend, as many of them have “natural” somehow incorporated into their brand name.

Another newer trend that takes the theme of natural pet food a step further has been the preparation of homemade meals for the family pet. Some owners believe that feeding their dogs homemade meals leads to “greater long term health benefits” because it is “more natural” or “organic” (Remillard). While there might be some significant advantages to feeding a homemade meal there are also some risks. Most owners who prepare meals for their dog use recipes that contain “excessive protein because of the perception that the diet that dogs and cats should be mostly meat” (Remillard). An all meat diet can have some significant nutritional drawbacks as was mentioned earlier. Because of this and other concerns owners who prepare their own dog foods also have to make sure to supplement the diet with vitamins and minerals. An example of a homemade dog food recipe calls for ten pounds of raw ground beef, eighteen eggs (including the shells), five cups uncooked white rice, one tube of LickOChops omega fatty acid supplement, and Dinovite supplement (“Easy Cooked Dog Food”).

Nutritional Diseases

A major aspect of feeding an animal is that good nutrition can be a significant tool in the management of disease. On the other hand, bad nutrition can lead to and be the cause of a variety of different health problems for the animal. Diseases of the dog that can be caused by poor diet and have particular relevance today include obesity and food allergies as well as pancreatitis and dental disease. These conditions can also therefore be managed by good nutrition. Diabetes mellitus, while not directly caused by a poor diet, is another syndrome that can benefit from nutritional management.

Obesity

One of the most frequently seen nutritional diseases in dogs, and other companion animals, is obesity (Case). In fact, obesity is the most commonly observed form of malnutrition in companion animals, in both the US and other industrialized countries (Case). The condition has become so common that it is estimated that “between 20% and 50% of dogs living in homes” are considered overweight or obese (Case). If the dog population in the United States is estimated to be around 72 million then there are least 14.4 million dogs that would qualify as obese (Case). Clinically, a dog would be classified as obese when their body weight reaches at least 15% above the ideal weight (Gossellin). The demographic of dog that is most often affected are middle aged adults, or those between five and eight years of age (Case). Younger adults or geriatric dogs tend to be less likely to develop obesity (Case). Neutered dogs of either sex are at a greater risk due to a decreased metabolic rate (Gossellin).

Obesity can be the result of an overly sedentary lifestyle as well as imbalances in nutrition. For many dogs living with a family in a developed country a "sedentary lifestyle has become the norm rather than the exception," making it much more likely for them to become overweight or obese (Case). In addition, many of these same dogs are provided with a "highly palatable and energy dense food source" (Case). These two factors can help lead to the development of an energy imbalance and subsequently obesity. In canines, and humans, obesity is associated with a variety of other medical conditions, including the development of glucose intolerance, abnormal insulin levels, hypertension, and altered lipid profiles (Case). Obesity can also be associated with a greater likelihood of developing conditions such as diabetes mellitus, cardiovascular disease and pulmonary disease (Case).

The most frequently prescribed treatment for obesity in dogs is a regime of increased exercise and decreased food intake. The guiding principle behind a reduced diet and increased exercise is that "weight loss should be gradual to minimize lean tissue loss" and to avoid regaining the weight (Gossellin). However, the management of obesity through such a program is often difficult due to its dependence on owner compliance. Owners may often feel that their dog is not getting enough to eat or is unhappy with their food, and so the owners will frequently have a hard time sticking to the regime. There are multiple dog foods out on the market that are specifically formulated for weight loss. These foods are typically formulated to be "palatable, low in calories, and to contain fiber to provide bulk" (Gossellin). An alternative approach to such a high fiber diet would be a diet rich in protein and low in carbohydrate, similar to the human Atkin's diet (Gossellin). In canines, a diet such as this has been found to reduce body weight while maintaining fat free mass (Gossellin). There are also now some pharmaceutical treatments for the management of obesity in dogs. Two examples are dirlotapide and mitratapide, both MTP inhibitors (Gossellin). MTP, microsomal triglyceride transfer protein, normally mediates the absorption of triglycerides and the secretion of chylomicrons from the intestine (Brookes). The MTP inhibitors, can therefore act within the endoplasmic reticulum of enterocytes by stopping the formation and release of chylomicrons in the lymphatics, thus fat digestion and absorption is impaired (Gossellin).

Pancreatitis and Diabetes Mellitus

Pancreatitis is a second disorder that can be linked to a nutritional cause. Pancreatitis is the inflammation of the pancreas, an organ involved in the production of hormones, such as insulin, as well as the production of pancreatic juices. These secretions aid in the digestion and absorption of various nutrients in the gastrointestinal tract. In dogs, it has been found that there is an association between pancreatitis and high fat diets (Hilton, 855). High amounts of fat in the diet could result in "high concentrations of triglyceride in and around the pancreas" this in turn could result in "excessive lipolysis with the release of large quantities of free fatty acids" (Hilton, 855). These free, unbound fatty acids can be very toxic and damaging to the tissues. While high fat diets can predispose animals to pancreatitis, obesity can also be a precursor to the disease (Hilton, 855). Pancreatitis in dogs can often become a problem because owners are unaware of the fat content in the food that they feed their animal. Combine this with the fact that people tend to over feed their dogs and you are left with the problem of dogs receiving too much energy dense food, in particular too much fat. Prior to the 1980's most dog foods were formulated with a moderate protein level and low lipid content, ~12% protein and ~8% lipid (Hilton, 855). However, in the 1980's changes came to the pet food industry, so that diets started to be formulated to be high in protein and to have a high lipid content, 25-30% protein and 15-20% lipid (Hilton, 855). These are classed as high energy diets and are similar to many of the diets that are listed in table 1.

Chronic damage to the pancreas has also been associated with an increased risk for canine diabetes. Pancreatitis has been determined to be the associated with ~28% of canine diabetes cases (Rand). Diabetes in dogs is most often seen in the form of type 1 diabetes, or insulin dependent diabetes (Rand). There is no evidence to suggest that type 2 diabetes occurs in canines, or that obesity is a significant risk factor for the development of diabetes in canines (Rand). Diabetes mellitus is a significant issue in dogs because of its increasing prevalence. Forty years ago 19 in 10,000 dogs visiting veterinary hospitals were diagnosed with diabetes; by 1999 this number had increased to 58 per 10,000 dogs (Rand). While there is an association between pancreatitis and diabetes, genetic predisposition and immune responses also play roles in the pathogenesis of the disease (Rand). In treating diabetes in canines often one of the most important factors is nutrition. Nutritional management will focus on providing adequate calories to the animal, maintaining a healthy weight in the animal, and reducing the clinical signs of diabetes (Fascetti). Diets prescribed to manage diabetes are often high in fiber. These high fiber diets are suggested because they promote slower digestion and absorption of carbohydrates, thereby preventing spikes in blood sugar after a meal (Fascetti).

Dental Disease

One disease that may not commonly be associated with nutrition by owners, but is affected by it none the less, is dental disease. This includes conditions such as gingivitis and periodontal disease. These conditions of the mouth can be affected by feeding practices that can help to minimize plaque and calculus formation (Case). Specifically, the form the food takes can have a significant impact on the risk of developing the disease. Diets that are based on a softer or wet dog food tend to be more likely to lead to disease symptoms than diets that are based on dry food (Case). This is because of the abrasiveness of the harder foods. Because of findings such as these, foods specifically labeled as dental diets have been formulated. These diets tend to include varying textures and different shaped and sized food pieces (Case). An example of such a diet can be seen in table 1, Hill's Science Diet Canine Adult Oral Care Dog Food. The only major difference between this food and others in the table is the texture and size of the food pieces. There are also a variety of different dental treats on the market as well, including Greenies Dental Chews and Natural Balance Dental Chews.

Food Allergies

Finally, food allergies are a condition that is a direct result of a dog's diet. Food allergy is defined as all the immune mediated reactions that follow food intake (Verlinden). This is distinct from food idiosyncracy which is an abnormal response to a food that is not immune mediated (Verlinden). Most dogs' reactions to substances such as food additives are food idiosyncracies rather than food allergies (Verlinden). Food allergy typically causes a variety of different gastrointestinal and dermatological signs in the dog (Verlinden). The most common symptom of food allergies is pruritis, or itching of the skin. This can either be all over the animal's body or localized to areas such as the face, paws, or ears (Verlinden). The gastrointestinal symptoms usually include vomiting, abdominal pain and diarrhea (Verlinden). Many different components of a dog's diet can act as food allergens, making it sometimes difficult to determine the exact cause of a food allergy. Common allergens in dogs include beef, dairy and wheat (Verlinden). Treatment of food allergies will involve removing the allergen from the animal's diet either through the use of a homemade diet or commercial novel protein diets. Homemade diets are not usually recommended for long periods of time because most are not nutritionally adequate for growth and development (Verlinden). Commercial hydrolyzed protein diets are also available, these are actually "real hypoallergenic diets" (Verlinden). These diets are processed such that proteins are broken down into smaller peptides that are small enough to not evoke an immune response (Verlinden).

Conclusion

Starting with the very first canids to inhabit the earth, the dog's diet has been based around meat. However, the canids have also evolved to be able to consume a variety of different foods. The dog's ancestors were mesocarnivores, able to consume both meat and foods of plant origin and the dog has continued this tradition, evolving to become an animal adapted to a variety of different food sources, including an increased ability to digest starch. Humans have taken advantage of this ability of the dog to adapt and change, both in terms of breeding a huge selection of different dogs, and in how we feed our dogs. From providing dogs with scraps and trash left over from our meals we moved to preparing meals specifically formulated for what we thought the dog needed to grow and thrive. What we as humans think the dog needs nutritionally, has of course changed through time as we learn more and more. The dog foods available to owners reflect these changes in knowledge, as well as different trends. On the present day market significant trends include the production of all natural diets and the inclusion of high quality ingredients, as well as a move towards grain free, meat first diets.

Nutrition in the dog has become even more important and relevant as dogs have moved into our homes and become part of the family. As dogs are treated more and more like members of the family they experience many of the same problems humans are facing, such as a rising incidence of obesity. Nutrition can play an important role in the development of some of these diseases, in particular obesity or pancreatitis, but it can also be an important tool in the management of disease.

Picking a dog food can be a hard process. In the end my family ended up choosing a food based on cost and whether or not Rufus would eat it. This may not be the best way to choose a diet for a dog, but it worked for us. Other considerations might also include the primary ingredient of the food as well as the amount of energy the dog will get from the food compared to how much exercise the dog engages in. Finally, no matter what food they are feeding, an owner should pay attention to the amount that they provide to their dog.

Tables

Brand Name	First Ingredient	Crude Protein	Crude Fat	Crude Fiber	Calorie Content (ME)	Price (per pound)
Authority	Lamb	22.0% min	12.0% min	4.0% max	405 kcal/cup	$1.11
Bil-Jac	Chicken	27.0% min	18.0% min	4.0% max		$2.13
Bil-Jac Large Breed Select	Chicken by products	23.0% min	16.0% min	4.0% max		$2.13
Blue Buffalo Basics Limited Ingredients	Deboned Salmon	22.0% min	14.0% min	5.0% max	377 kcal/cup	$2.99
Blue Buffalo Life Protection	Deboned Chicken	24.0% min	14.0% min	4.0% max	442 kcal/cup	$2.07
Blue Buffalo Wilderness	Deboned Chicken	34.0% min	15.0% min	6.5% max	410 kcal/cup	$3.09
Blue Freedom Grain Free	Deboned Chicken	24.0% min	14.0% min	7.0% max	391 kcal/cup	$2.73
Eukanuba Adult Weight Control	Corn Meal	19.0% min	9.0% min	11.0% max	272 kcal/cup	$2.33
Eukanuba Large Breed	Chicken	23.0% min	13.0% min	5.0% max		$1.36
Hill's Science Diet Adult Large Breed	Whole Grain Corn					$1.14
Hill’s Science Diet Oral Care	Chicken by product meal	21.0% min	13.0% min	12.0% max		$1.63
Iams ProActive Health Adult Large Breed	Chicken	22.5% min	12.5% min	5.0% max		$1.07
Iams ProActive Health Mature Adult	Corn Meal	24.0% min	10.0% min	12.5% max		$1.07
Nature's Recipe	Lamb meal	20.0% min	12.0% min	4.0% max		$1.47
Nature's Recipe Grain Free Easy to Digest	Salmon	27.0% min	12.0% min	4.0% max		$2.17
Nutro Natural Choice	Lamb meal	22.0% min	14.0% min	3.5% max		$2.53
Nutro Natural Choice Grain Free	Venison meal	21.0% min	12.0% min	3.0% max		$2.79
Pedigree Adult Complete Nutrition	Ground Whole Corn	21.0% min	10.0% min	4.0% max	335 kcal/cup	$0.73
Purina One SmartBlend	Chicken	26.0% min	16.0% min	3.0% max		$1.09
Purina Pro Plan Adult Shredded Blend	Chicken	26.0% min	16.0% min	3.0% max		$1.67
Purina Pro Plan Sensitive Skin and Stomach	Salmon	26.0% min	16.0% min	4.0% max	419 kcal/cup	$1.83
Royal Canin German Shepherd Food	Brewer's rice	22.0% min	17.0% min	5.0% max	322 kcal/cup	$1.82

Science Diet Sensitive Stomach	Brewer's rice	21.0% min	12.0% min	4.0% max		$2.26
Simply Nourish Limited Ingredient	Dried Sweet Potato	24.0% min	12.0% min	5.0% max		$2.54
Wellness Core Grain Free	Deboned Turkey	34.0% min	16.0% min	4.0% max	421 kcal/cup	$3.17

Table 1. Dry dog foods

Brand Name	First Ingredient	Crude Protein	Crude Fat	Crude Fiber	Calorie Content (ME)	Price (per pound)
Authority	Beef	11.0%	8.0% min	6.0% max	85 kcal/oz	$2.99
Fresh Pet	Chicken	9.0% min	6.0% min	1.5% max		$2.83
Pet Botanics Grain Free Rolled Dog Food	Chicken	14.0% min	8.0% min	6.0% max		$2.99

Table 2. Fresh refrigerated foods

Brand Name	First Ingredient	Crude Protein	Crude Fat	Crude Fiber	Moisture Content	Price (per oz)
Blue Home style Recipe	Chicken	7.5% min	4.5% min	2.0% max	78.0% max	$0.19
Castor and Pollux Organiz	Organic chicken	9.0% min	5.0% min	1.4% max	81.0% max	$0.19
Cesar Canine Cuisine	Water, beef by products	8.0% min	3.0% min	1.0% max	84.0% max	$0.21
Halo Spot's Choice	Turkey	9.0% min	6.0% min	0.75% max	78.0% max	$0.22
Hill's Ideal Balance	Chicken Broth	5.5% min	2.5% min	1.5% max	78.0% max	$0.19
Pedigree Healthy Vitality	Chicken by products	8.0% min	6.0% min	1.5% max	78.0% max	$0.05
Pro Plan Savor	Water, Beef	9.0% min	2.0% min	1.5% max	82.0% max	$0.18
Purina Beneful chopped blends	Water, beef	10.0% min	2.0% min	1.5% max	76.0% max	$0.18
Royal Canin Beauty Dog Food	Water, pork by products	7.5% min	4.0% min	1.5% max	78.5% max	$0.27
Simply Nourish	Chicken Broth	6.0% min	1.0% min	0.5% max	85.0% max	$0.24
Variety Pet Foods	Turkey	8.0% min	6.0% min	1.3% max	78.0% max	$0.34
Wellness simple limited ingredient	Lamb	8.0% min	8.0% min	1.0% max	78.0% max	$0.22

Table 3. Canned foods

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