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UNP-35

Canine Feeding and Nutrition

Introduction

Although canines (dogs) are classified as carnivores, they like a variety of foods. Different foodstuffs are mixed to provide a balanced diet that meets the dog's nutrient requirements at a specific stage of life. Whether commercially manufactured or home prepared, dogs need to consume a nutritionally complete diet daily to keep them physically fit and healthy. Like humans, dogs have requirements for essential food constituents such as carbohydrates, fats, proteins, vitamins, minerals, and water.

Nutrients

Carbohydrates. Although there is no known dietary requirement for carbohydrates in dogs, they are an excellent source of energy. Cereal grains such as corn, barley, rice, and wheat have a high content of starch, which provides a source of energy in most commercial dog foods. Milk contains a large amount of the carbohydrate lactose, but it may cause diarrhea in some dogs. On the other hand, foodstuffs such as beet pulp, which contains high levels of insoluble carbohydrates (fiber), helps with the prevention and treatment of diarrhea. Furthermore, fiber, which is composed of cellulose, hemicellulose, lignin, and pectin, also decreases the retention time of feces in the large intestine, hence, helping to prevent and treat constipation. An increase in the amount of fiber in the diet can also benefit overweight dogs by maintaining the animal's sensation of fill, hence, decreasing the caloric intake.

Fats. The most concentrated source of energy in the diet is fat. This nutrient consists of glycerol and fatty acids, which can be saturated or unsaturated. However, the dog requires essentially linoleic and arachidonic acid, both of which must be provided in the diet. Fats used commercially include cottonseed oil, hydrogenated vegetable oil, poultry fat, lard, and tallow. Furthermore, fats contribute to palatability and texture of diets, and carry the fat-soluble vitamins A, D, E and K. The most prevalent problem related to fat is overconsumption and obesity. However, dogs fed a low fat diet very often will have a dull coat and dry skin. Therefore, a balanced diet custom-tailored for the specific life cycle of the dog is the best solution to prevent fat-related problems.

Proteins. One of the most important nutrients in the diet is protein. However, what dogs really need are the amino acids that make up the protein. Of the 20 amino acids required, dogs can synthesize half of them, while the remaining ones must be consumed. The latter ones, called essential amino acids, include arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Since each protein contains different amounts of amino acids, some proteins are better than others. Foodstuffs of animal origin such as beef, chicken, lamb, and turkey have a better protein quality than foodstuffs of plant origin such as soybean meal and corn. Most commercial diets provide adequate protein sources for the different life stages of the dog.

Vitamins. Vitamins are organic compounds that are essential for normal metabolism. They can be classified as fat-soluble or water-soluble. Vitamins A, D, E and K are fat-soluble, while B-complex vitamins such as thiamin (B_1), niacin, riboflavin (B_2), pantothenic acid (B_5), pyridoxine (B_6), folic acid, cobalamin (B_{12}), and biotin are water-soluble. Vitamin C (ascorbic acid) is also classified as water-soluble. These organic substances are naturally present in small amounts in most foodstuffs, hence, the commercial manufacture of vitamin supplements for dogs. It is worth cautioning that because fat-soluble vitamins are commonly stored in fat tissue cells within the body, they pose a big threat if oversupplemented. Water-soluble vitamins, on the other hand, are easily eliminated from the body

via the urine, hence, a minimal risk of toxicity.

Minerals. Like vitamins, minerals play very important roles in physiology and metabolism. These inorganic nutrients are divided into macro and micro categories. The macro-minerals are needed in larger amounts in the diet than the micro-minerals (trace elements). However, both perform many different functions including bone formation, blood clotting, transport of oxygen in the blood, muscle contraction, and nerve impulse transmission. Calcium and phosphorus are the major minerals involved in the formation of bone and cartilage in the body. Legumes, dairy products, and bones contain large quantities of calcium, while muscle and organ tissues are high in phosphorus. Therefore, minerals must be added in order to provide the correct calcium to phosphorus ratio (1.2:1) in the diet proper. A deficiency, an excess, or an imbalance of these minerals, can cause severe skeletal deformities. Other important macro-minerals include magnesium, potassium, sodium, and chloride. Important micro-minerals among others are copper, iodine, iron, manganese, selenium, and zinc.

Water. Water is the most important of all nutrients. It helps to regulate the body's temperature, and, as the principle constituent of blood, transports nutrients to the different body tissues, thus removing metabolic-end products from the dog's system. Furthermore, some chemical reactions within the animal cell require the addition or subtraction of water. Therefore, the dog requires ad libitum water of the highest quality.

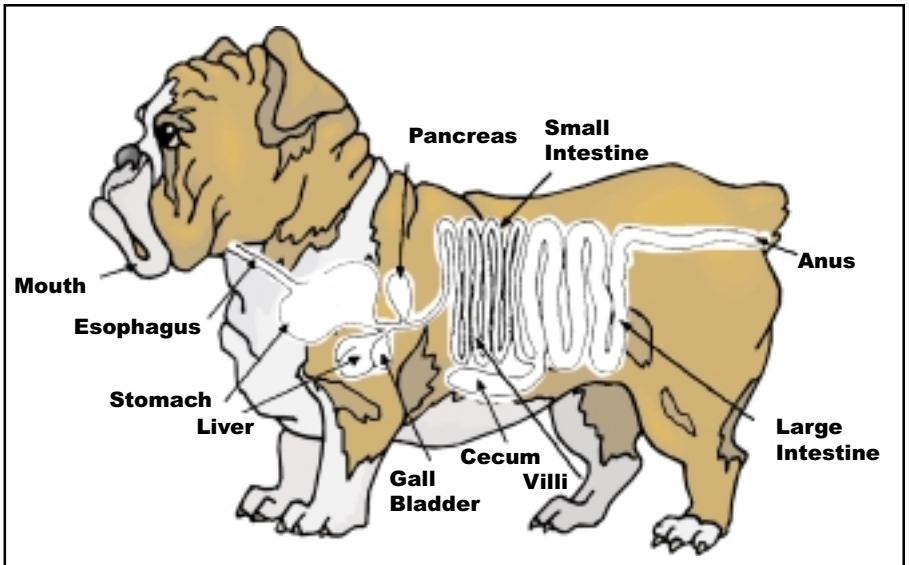

Figure 1. The gastrointestinal tract of the dog.

Digestion and Absorption

The dog has a monogastric gastrointestinal tract (Figure 1) that includes the mouth, esophagus, stomach, small intestine, and large intestine. This tract works with the aid of the salivary glands, pancreas, liver, and gallbladder to break down the large forms of nutrients in the food into simple forms that the body can absorb and utilize.

Mouth and Esophagus. The digestive process begins in the mouth with the mechanical breakdown of food into smaller particles through the action of the teeth (28 in puppies and 42 in adult dogs) that line the upper and lower jaws. Saliva secreted by the salivary glands aids to lubricate the food. Unlike humans, the enzyme ptyalin, an alpha-amylase, is not found in the saliva of dogs.

After swallowing, food moves rapidly through the esophagus to the stomach. The cardiac sphincter, which is located at the base of the stomach, relaxes to allow food to enter from the esophagus into the stomach, and then immediately closes to prevent the acidic stomach contents from backing up into the lower esophagus.

Stomach. The gastric juice, which is produced by the cells of the stomach, contains mucus, hydrochloric acid, pepsinogen (the inactive form of the enzyme pepsin), and the enzyme gastric lipase. Hydrochloric acid influences the conversion of pepsinogen to its active form, pepsin, which partially hydrolyzes protein to smaller polypeptides while in the stomach. The enzyme gastric lipase, which plays a minor role in the digestion of fats, hydrolyzes triglycerides into fatty acids and glycerol. The resulting chyme (a semifluid mass of partially digested food and digestive juices) then passes into the small intestine via the pyloric sphincter that closes instantly to prevent reflux back into the stomach.

Small Intestine. The digestion and absorption of nutrients in the body occurs primarily in the small

intestine. The duodenum (the section of the small intestine closest to the stomach) is mainly responsible for digestion, while the jejunum (the middle section of the small intestine) and the ileum (the terminal section of the small intestine) are mainly responsible for absorption. To digest carbohydrates, fats, and proteins, the pancreas and the walls of the small intestine secrete into the intestinal lumen the following enzymes:

- **pancreatic amylase** converts starch into maltose
- **intestinal maltase** converts maltose into glucose
- **intestinal lactase** converts lactose into glucose and galactose
- **intestinal sucrase** converts sucrose into glucose and fructose
- **pancreatic lipase** converts triglycerides into monoglycerides and fatty acids
- **intestinal lipase** converts triglycerides into glycerol and fatty acids
- **trypsin and chymotrypsin** (secreted by the pancreas) converts proteins and polypeptides into peptides
- **pancreatic carboxypeptidase** converts peptides into small peptides and amino acids
- **intestinal aminopeptidase** converts peptides into amino acids

It should be mentioned that bile, which is secreted by the liver and stored in the gallbladder, emulsifies fats to provide sufficient surface area for efficient digestion.

As end products of digestion are made available, they are absorbed across the intestinal wall into the body. The surface area available for absorption is increased by small fingerlike projections called villi that cover the intestinal wall. Each cell lining the surface of each villus is covered with hairlike projections called microvilli. As nutrients travel through the small intestine, they are trapped in the villi of the intestinal wall and absorbed through the microvilli into the lining cells. The nutrients absorbed then pass into the interior of the villi that contain veins, arteries, capillaries, and lymphatic vessels for transport to the tissues of the body.

Large Intestine. The contents of the small intestine enter the large intestine through the ileocecal valve, which then closes to prevent material from backing into the ileum of the small intestine. The large intestine, which includes the cecum, colon, and rectum, is responsible mainly for the bacterial digestion of dietary fiber and absorption of water and minerals. Furthermore, the bacterial population present in the colon also produces some vitamins and various gases. Feces, which consists of undigested food, water, sloughed cells, digestive secretions, and bacteria, then passes into the rectum and is excreted through the anal canal.

Body Tissue Metabolism

Catabolism. Tissue cells break down nutrients through thousands of chemical reactions. These reactions release high-energy electrons that are received and carried by coenzymes such as nicotinamide adenine dinucleotide (NAD^+) and flavin adenine dinucleotide (FAD^+). When these coenzymes accept two high-energy electrons, they pick up two hydrogen (H) ions to form NADH + H^+ and $FADH_2$, respectively. When each pair of electrons are passed along a sequence of linked reactions in the respiratory chain (Figure 2), they generate adenosine triphosphate (ATP). Just as automobiles require gasoline for fuel, body tissue cells require ATP

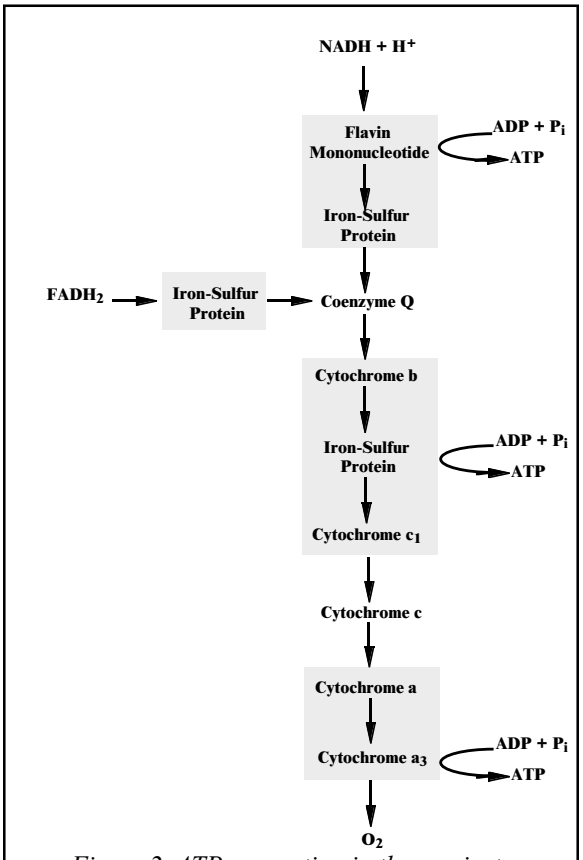

Figure 2. ATP generation in the respiratory chain of the mitochondria.

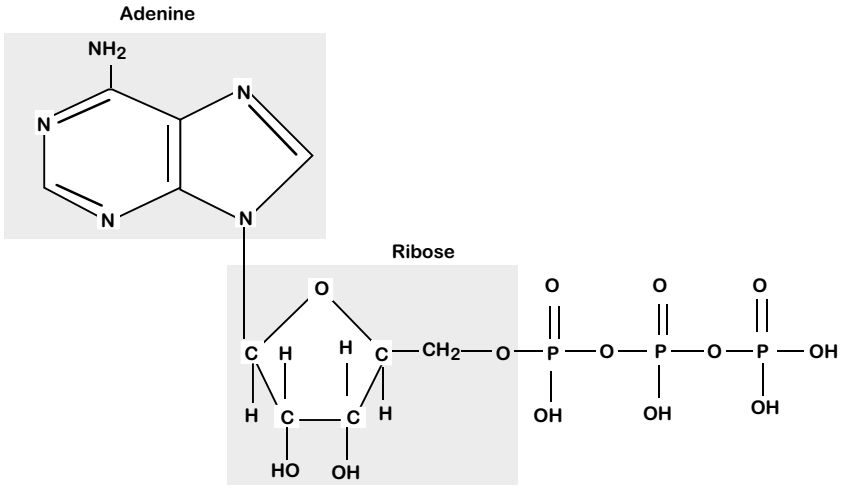

Figure 3. ATP is required by body tissue cells to sustain life.

(Figure 3) to sustain life. When the bonds between the phosphates of ATP break, they release the stored energy to power biosynthesis and biological work. The complete breakdown of nutrients for energy occurs through biochemical pathways such as glycolysis, β-oxidation, transamination, oxidative deamination, and the citric acid cycle.

Anabolism. While some tissue cells are breaking down nutrients to obtain energy, other tissue cells are synthesizing them. When the body has an excess of nutrients, biosynthesis takes place. Biosynthetic pathways that are active in tissue cells include gluconeogenesis, glycogenesis, lipogenesis, ketogenesis, transamination, and protein synthesis. The sequence of amino acids in a protein is specified by the sequence of nitrogenous bases (adenine (A), thymine (T), guanine (G), and cytosine (C) in a deoxyribonucleic acid (DNA) molecule. However, the sequence of bases in a DNA molecule (Figure 4) has to first be transcribed to another molecule called messenger ribonucleic acid (mRNA). The mRNA, that is complementary to the DNA, except that the mRNA contains uracil (U) instead of thymine, then carries the genetic information from the nucleus to the ribosomes of the cell. On these organelles, the amino acids are inserted at their corresponding site on the mRNA, and subsequently, attached to the growing polypeptide chain. This process of protein synthesis entails initiation, elongation, and termination.

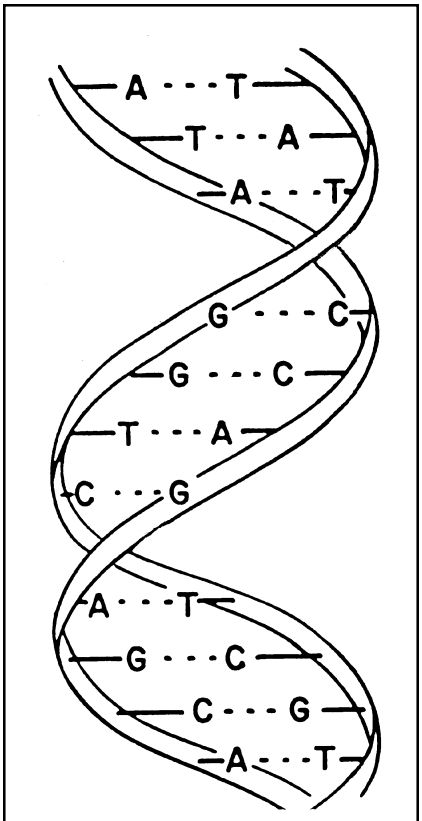

Figure 4. In the double-stranded DNA, adenine pairs with thymine while guanine pairs with cytosine.

The balance between breakdown and synthesis of nutrients is regulated by hormones and other factors. Among the regulatory hormones is insulin, which is secreted by the pancreas to reduce the amount of glucose in the blood. When the pancreas fails to produce the hormone, Type I diabetes mellitus occurs. On the other hand, when insulin levels are adequate but body tissue cells have difficulty uptaking glucose, Type II diabetes mellitus occurs. This type of diabetes is almost always associated with obesity, the most common form of malnutrition in dogs in the United States. However, other factors such as breed, reproductive status, level of activity, and type of diet may affect obesity in dogs. Therefore, a nutritional management program must be developed and implemented to effectively manage obesity and treat diabetes mellitus. Furthermore, because of the large variety of dog food available today, owners must have some basic knowledge of nutrition in order to select the appropriate diet for a particular stage of life, level of activity, and health status.

Guidelines for Selecting Foods and Feeding Dogs

- Make sure that the label in commercially manufactured foods has the Association of American Feed Control Officials (AAFCO) guarantee.
- Be certain that the food has an expiration date.

- Look for meat (beef, chicken, lamb or turkey) as the first ingredient, rice as the main grain in the formula, and mixed tocopherols (vitamin E) as preservatives. It's worth mentioning that foods preserved with vitamins have a shorter shelf life than foods preserved with butylated hydroxyanisole (BHA) or butylated hydroxytoluene (BHT). However, according to some research, very high doses of these chemicals may cause cancer.
- Store food in a sealed container in a cool, dry place.
- If the dog has a special dietary requirement that cannot be met by commercial foods, consider feeding homemade diets.
- Feed the dog according to correct body weight and condition, and consider factors such as growth, adult maintenance, level of activity, gestation, lactation, and age. Use the National Research Council's (NRC) Nutrient Requirements of Dogs (1985).
- When changing foods, mix 1/4 of the new food to 3/4 of the old food, and increase gradually to prevent gastric upsets. Watch the dog's stool, weight, and coat while changing foods.
- Feed adult dogs twice a day to prevent gorging on a single meal and to reduce the occurrence of gastric upsets. Allow approximately 20 minutes for the dog to clean the bowl.
- Make sure that puppies consume colostrum (first milk) within the first 36 to 48 hours after birth (Figure 5). The absorption of colostral immunoglobulins (antibodies) across the intestinal wall decreases thereafter, hence, reducing the chances of survival greatly.
- Make sure that the dog has fresh and clean water at all times.

Conclusion

Like humans, dogs require a diet that contains the correct amounts of carbohydrates, fats, proteins, vitamins, minerals, and water that provide sufficient energy to meet the daily needs of their particular life cycle. Dietary requirements for dogs can vary according to breed, stage of life, level of activity, health status, living conditions (indoor or outdoor), and season. If the dog has a good body weight and condition, healthy skin and coat, is active, and receives good marks from annual medical checkups (Figure 6), the owner has done well. However, if the food is causing problems, the owner can take steps to correct matters by changing food, having some tests done on the dog, or make other adjustments as necessary.

Figure 5. Puppies must consume colostrum (first milk) within the first 36 to 48 hours after birth.

Figure 6. If the dog receives good marks from annual checkups, the owner has done well.

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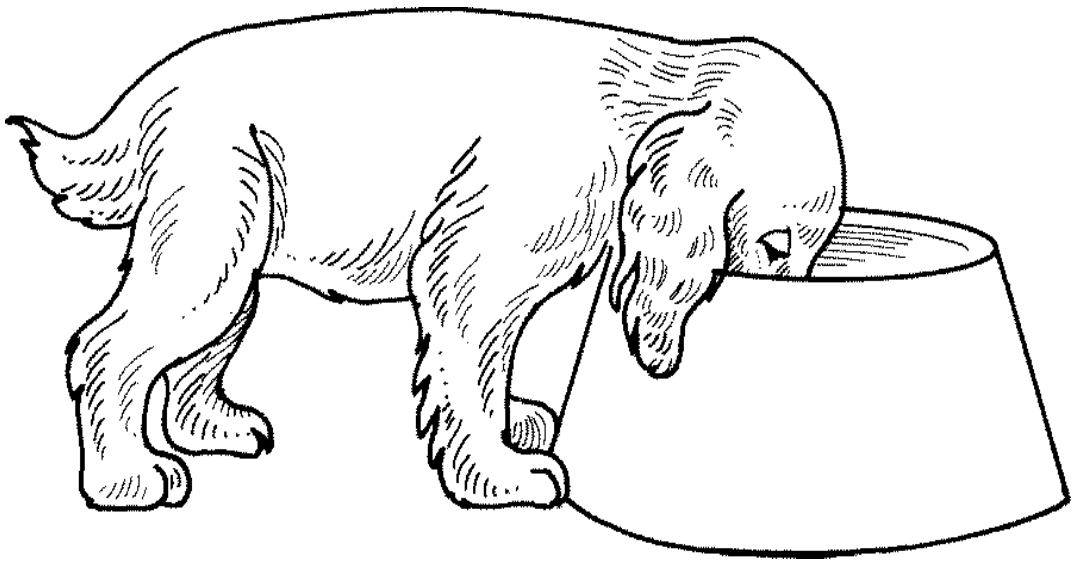
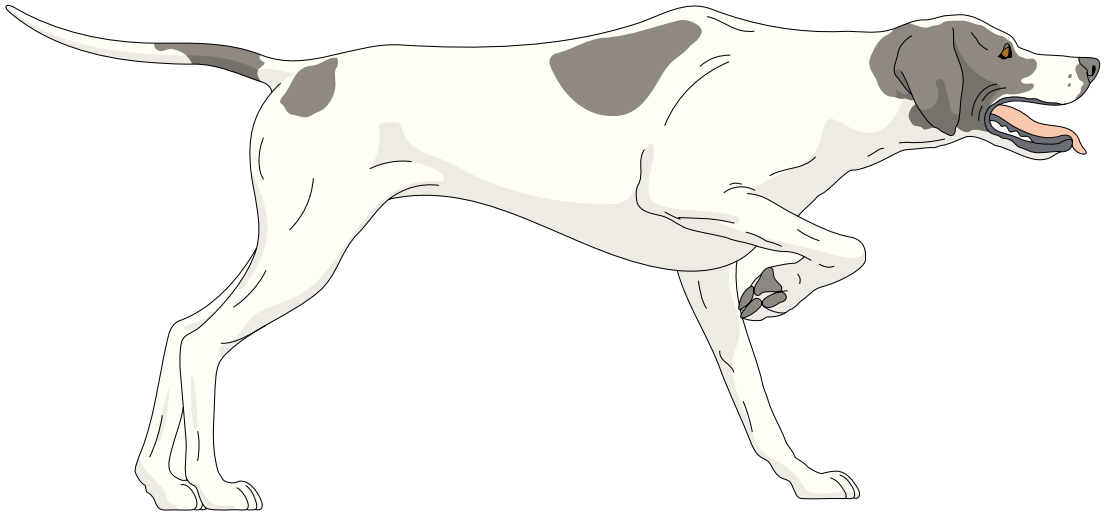


Allow approximately 20 minutes for the dog to clean the bowl.



Energy extracted from food is essential for biological work.

Good body weight and a healthy skin and coat are indicators of wellness.

A nutritionally complete diet keeps the dog physically fit and healthy.

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