The first studies on plasma lipoproteins were conducted in the 1920s. Horse sera were used, and a high-density lipoprotein (HDL) was isolated and described. Widespread interest in plasma lipids and lipoproteins stemmed from the observations of atheroma in young soldiers who were casualties during World War II. Because of the role of lipoproteins in cholesterol transport and a potential causal link to heart disease in humans, specific efforts were made to isolate plasma lipoproteins of low density with β-electrophoretic mobility from the HDL fraction with α-mobility. The advent of technologic advances such as analytical ultracentrifuges made it possible to study hydrodynamic behaviors of the lipoproteins. This led to the discovery of less dense very-low-density lipoprotein (VLDL) and intermediate-density lipoprotein (IDL) forms and to the current classification of good (ie, HDL) and bad (ie, low-density lipoprotein [LDL]) cholesterol carriers.

A major impact on our knowledge of lipid and lipoprotein metabolism was the discovery of familial gene mutations in humans that resulted in alterations of major lipoproteins, key enzymes, and cellular receptors that encompass the metabolic determinants of lipoprotein metabolism. Animals subjected to disease models and, more recently, the availability of transgenic mice also enabled numerous important contributions in this field. These remain important, even as new technologic advances are applied to improve our understanding of normal and disease states relating to plasma lipid biochemistry.

Plasma Lipoproteins and Atherosclerosis

An increased risk of developing atherosclerosis is associated epidemiologically with increased concentrations of total plasma cholesterol and LDL-cholesterol (LDL-C) and decreased concentrations of HDL-cholesterol (HDL-C). The ratio between concentrations of LDL-C and HDL-C or between their major apoproteins is considered by some authors to be a better predictor of the risk of developing coronary heart disease than evaluation of concentrations of LDL-C or HDL-C alone. Beneficial effects of HDL-C are believed to be a result of their role in reverse cholesterol transport (RCT).

Atherosclerotic lesions are characterized by the accumulation of fatty acid esters of cholesterol (cholesteryl esters) originating primarily from plasma LDL. However, VLDL and IDL may also accumulate in arteries. The accumulation of atherogenic lipoproteins initially involves the influx of particles into the intima following endothelial injury. If retained in the intima, degradation and accumulation of the influx particles by arterial cells are part of the atherogenic process.

In addition to increased concentrations of plasma LDL, per se, the formation of oxidized lipoproteins is also atherogenic. These modified lipoproteins may play a role in the formation of foam cells and development of lesions. Oxidative modification involves lipid peroxidation, which enhances recognition and uptake of LDL by macrophages. Even minimally modified LDL with low amounts of lipid peroxidation appear to be atherogenic because, in vitro, they stimulate expression of chemotactic proteins and adhesion of monocytes to the endothelium. Evidence exists for the in vivo oxidative process, and various antioxidants appear to retard formation of lesions in animals exposed to various disease models.

Lipid Transport in the Circulation

Role of plasma lipoproteins in lipid transport—Transport of water-insoluble lipids in the aqueous environment of the circulation requires specific protein-lipid complexes. In the circulation, nonesterified fatty acids form complexes with albumin, albeit only briefly, because they are readily taken up by tissues for metabolism. Triglycerides, phospholipids, and free and
esterified cholesterol are transported as lipoprotein complexes associated with specific proteins known as apolipoproteins (ie, apoproteins). Molecular complexes of these materials consist of an amphoteric shell of apoproteins, free cholesterol, and phospholipids surrounding a hydrophobic core of triglyceride and cholesteryl esters primarily in a spherical particle. Apoproteins have structural and functional attributes that serve to help direct lipoprotein metabolism via receptor- and non–receptor-mediated phenomena, as well as enzymatic and exchange reactions; thus, apoproteins serve as regulators of lipid metabolism.

Fractionation and classification of lipoproteins—Plasma lipoproteins differ in size, density, electrical charge, lipid and apoprotein composition, and metabolic function. They are characterized on the basis of their hydrated density (ultracentrifugal behavior), electrophoretic mobility on agarose or polyacrylamide gels, chromatographic separation (gel-filtration or ion-exchange affinity), or chemical precipitation (heparin-manganese chloride). Lipoproteins of dogs and cats are similar to those of humans, but important species differences exist.

Four main classes of lipoproteins are recognized (ie, chylomicrons, VLDLs, LDLs, and HDLs). There also are IDLs, with hydrated density between that of VLDLs and LDLs. Within the LDL and HDL categories, lipoprotein subclasses are also recognized and usually referred to via subscripts, such as HDL₁ or HDL₂. A full description of these subclasses may be found elsewhere. The classes of lipoproteins vary among dogs, cats, and humans (Table 1).

Metabolism of exogenous (dietary) lipid—Chylomicrons are the largest of the lipoproteins and are involved in the transport of dietary lipid (primarily triglycerides) from the small intestine after absorption (Fig 1). Absorption of dietary triglycerides is facilitated by pancreatic lipase within the intestinal lumen, which causes release of fatty acids, monoglycerides, and diglycerides. Inside enterocytes, glycerides are reesterified with fatty acids to produce triglycerides, which are then combined with free and esterified cholesterol, phospholipids, and the apo B₄₈ protein to form chylomicrons. These triglyceride-rich particles are secreted into lacteals and enter the general circulation, where they acquire.jpg

---

Table 1—Comparison of lipoproteins in dogs, cats, and humans

<table>
<thead>
<tr>
<th>Lipoprotein</th>
<th>Function</th>
<th>Species</th>
<th>Size (nm)</th>
<th>Hydrated density (g/mL)</th>
<th>Electrophoretic mobility</th>
<th>Major apoproteins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chylomicron</td>
<td>Dietary lipid transport</td>
<td>Dogs, cats, and humans</td>
<td>75–1,200</td>
<td>&lt; 0.960</td>
<td>Origin</td>
<td>B₄₈</td>
</tr>
<tr>
<td>VLDL</td>
<td>Hepatic triglycerides, cholesterol transport</td>
<td>Dogs and cats</td>
<td>30–80</td>
<td>0.093–1.006</td>
<td>Pre-β</td>
<td>B₁₀₀, B₄₈, E, and C</td>
</tr>
<tr>
<td>LDL</td>
<td>Cholesterol transport</td>
<td>Dogs and cats, Humans</td>
<td>18–25</td>
<td>1.019–1.087</td>
<td>β</td>
<td>B₁₀₀ and B₄₈</td>
</tr>
<tr>
<td>HDL₁ (HDLc)</td>
<td>Lipid transport, reverse cholesterol transport</td>
<td>Dogs</td>
<td>10–35</td>
<td>1.025–1.100</td>
<td>α-2</td>
<td>E, A, and C</td>
</tr>
<tr>
<td>HDL₂</td>
<td>Lipid transport, reverse cholesterol transport</td>
<td>Dogs and cats, Humans</td>
<td>9–12</td>
<td>1.063–1.100</td>
<td>α-1</td>
<td>E, A, and C</td>
</tr>
<tr>
<td>HDL₃</td>
<td>Lipid transport, reverse cholesterol transport</td>
<td>Dogs and cats, Humans</td>
<td>5–9</td>
<td>1.100–1.210</td>
<td>α-1</td>
<td>A and C</td>
</tr>
</tbody>
</table>

VLDL = Very-low-density lipoprotein. LDL = Low-density lipoprotein. HDL = High-density lipoprotein.
apo C and apo E peptides from HDLs, thereby providing the determinants of their metabolic fates.

One of the apo C peptides (ie, apo C-II) functions as a cofactor for lipoprotein lipase. The reaction releases fatty acids and glycerol from chylomicrons as they travel through capillary beds of adipose and muscle tissues and makes them available for subsequent metabolism. Lipoprotein lipase is synthesized in peripheral cells and transported to capillary endothelium, where it is firmly anchored by proteoglycan chains of heparin sulfate. It typically is not found floating freely in the blood but is released into the circulation following an injection of heparin.

Hydrolysis of core triglycerides results in a reduction in size of chylomicrons. Excess surface materials, such as apo C and phospholipids, build up until a point at which these components are transferred back to HDL (Fig 1). Triglyceride-depleted particles (termed chylomicron remnants) can be rapidly removed from the circulation by virtue of hepatic-receptor binding of their remaining apo E peptide.27

Metabolism of endogenous (synthesized) lipids—The other classes of lipoproteins (ie, VLDL, LDL, and HDL) are involved in transport and metabolism of endogenously synthesized lipids (Fig 2). The VLDLs are the primary carriers of triglycerides in the postabsorptive state. They are synthesized mainly in the liver, although some intestinal contribution has been observed.28 Endogenously synthesized triglycerides combine with cholesterol, cholesteryl esters, phospholipids, and apo B_{100} peptide to form VLDLs. Dogs are 1 of the species that secrete apo B_{48}-containing VLDLs.29

Inclusion of this apopeptide may explain the low concentrations of apo B-containing lipoproteins in dogs because of the rapid recognition and hepatic-receptor binding of these particles that result in their efficient clearance.28,30

The metabolic fate of VLDLs is similar to that of chylomicrons. Once secreted, VLDLs also acquire apo C and apo E peptides, release fatty acids and glycerol, are delivered via tissue perfusion to capillary beds, are hydrolyzed to produce remnant products, and undergo hepatic uptake. Circulating VLDLs can also undergo further transformation to form LDLs. This process appears to be dependent on lipoprotein lipase as well as a similar endothelial lipase found in the liver. That enzyme, hepatic triglyceride lipase, is located on endothelial cells lining the liver sinusoids. Its function is to hydrolyze triglycerides and phospholipids from lipoprotein particles. As additional delipidation proceeds, the VLDLs are again reduced in size to form LDLs, which contain primarily cholesterol esters and apo B_{100}. These LDLs can also bind specific receptors (apo B-E receptors) that are widely distributed throughout tissues. In this manner, cholesterol is delivered for production of steroid hormones, synthesis of cell membranes, and hepatic metabolism.31 Hepatic triglyceride lipase also hydrolyzes the triglycerides in HDLs,25,26 and fatty acids and cholesterol are subsequently released for uptake by the liver. Uptake of cholesterol by the liver is required for the proper metabolism of HDLs. With the hydrolysis of phospholipids, large HDL$_2$ particles are converted to smaller, denser HDL$_3$ particles. Similar to the situation for lipoprotein lipase, hepatic triglyceride lipase is firmly anchored to the endothelial cells of the liver and is released into the circulation following an injection of heparin.

The HDLs are relatively abundant in dogs and cats. They serve as donors and acceptors of apo C, apo E, and various lipids from other lipoproteins in the circulation. In addition, they are involved in the return of cholesterol back to the liver for excretion or redistribution (Table 1; Fig 2). Synthesized primarily in the liver, discoidal-shaped HDL$_2$ particles are secreted as a phospholipid bilayer containing cholesterol and its protein determinant, apo A-I. In the circulation, apo A-I functions as a cofactor for the lecithin-cholesterol acyl transferase (LCAT) reaction. This reaction is important because it is the first metabolic step in the process of RCT.

Mechanisms of RCT—It is believed that HDLs exert a protective effect for the development of coronary artery disease because of their role in RCT.32 Reverse cholesterol transport refers to the efflux of cholesterol from peripheral tissues (including arteries) to HDLs for esterification and subsequent hepatic clearance. Cholesterol esters are retained by HDLs or transferred to VLDLs or LDLs for transport to the liver for disposal. This process is believed to be an

Figure 2—Schematic depicting enzymatic and exchange reactions during metabolism of plasma lipoproteins. B$_48$ = Apo B$_{48}$. C = Apo C. E = Apo E. CE = Cholesterol ester. HDL = High-density lipoprotein. LCAT = Lecithin-cholesterol acyl transferase. LDL = Low-density lipoprotein. TG = Triglyceride. VLDL = Very-low-density lipoprotein. See Figure 1 for remainder of key.
efficient way of redistributing cholesterol among lipoproteins for reuse by peripheral tissues or removal from the circulation through delivery to the liver and excretion in bile. In humans, 2 enzymes participate in the process (LCAT and cholesteryl ester transfer protein [CETP]). It is of interest that CETP activity has not been documented in dogs or cats.33,34

The function of LCAT is to catalyze the conversion of cholesterol and phospholipid into cholesterol ester and lysophosphatidylcholine (Fig 3).35 Lecithin:cholesterol acyltransferase binds to HDLs after they are initially released into the circulation as small discoidal bilayers of phospholipid. Lecithin-cholesterol acyltransferase requires apo A-I and, possibly, apo C-I as cofactors. Apo A-II is also found on HDLs and may be an inhibitor of LCAT. As free cholesterol is esterified, cholesterol esters move into the core of the particle, providing room on the surface of the particle for additional free cholesterol from peripheral tissues. During this process, HDL2 particles are transformed from discoidal nascent HDLs to HDL3 particles and finally back to larger, less dense HDL2 particles. Cholesterol esters can then be transported to the liver via the HDLs. Activity of LCAT is positively related to total plasma cholesterol, LDL-C, and apo B concentrations.36

In humans, a further lipid exchange process takes place between the HDLs and apo B-containing lipoproteins (ie, chylomicrons, VLDLs, and LDLs). This exchange is mediated by CETP and results in exchange of triglyceride from the apo B lipoproteins with cholesterol ester from the HDLs (Fig 3). Cholesteryl ester transfer protein is bound to HDL particles. In this way, cholesterol esters can be transported to the liver and secreted in bile. Large VLDLs are the preferred acceptors for cholesterol esters, and the exchange appears to be related to the quantity of triglyceride-rich particles available.37

The resultant cholesterol ester-rich apo B-containing lipoproteins are taken up during hepatic receptor-mediated events, and RCT is completed. The HDLs remaining in the circulation are relatively glyceride-rich and are known as HDL2 particles. Hepatic triglyceride lipase helps remove this glyceride-associated fatty acid, and in the process, HDL3 particles are again formed. In this way, HDLs are prepared for reuse in additional RCT events.

**LCAT and CETP function together**—The enzymes LCAT and CETP work in concert in the human circulatory system.38,39 Together with HDLs and apo A-I as a cofactor, LCAT uses phospholipids to esterify free cholesterol that has been effluxed from extrahepatic tissues. This process results in larger HDLs (HDL3 and HDL2). At this juncture, cholesterol esters have 3 routes: cholesterol esters can be taken up by the liver without HDL endocytosis by the SR-B1 receptor; HDLs may be taken up directly by the liver via apo E receptors; or in humans (but not dogs or cats), cholesterol esters from HDLs may be exchanged for triglycerides of apo B-containing lipoproteins (VLDLs and LDLs). In the first 2 routes, cholesterol esters are catabolized and removed from the body. In the third route, CETP facilitates the exchange of cholesterol ester of HDL2 particles with triglyceride from VLDLs or LDLs. Some believe that this process may be antiatherogenic because triglycerides of HDLs can be hydrolyzed in the liver, resulting in the conversion of HDL2 particles to HDL3 particles. The smaller, denser HDL3 particles can then recirculate to the periphery to again scavenge cholesterol.

**CETP may be atherogenic**—An additional effect of RCT is endocytosis of the apo B-containing VLDL and LDL remnants that contain cholesterol. This is accomplished in the liver via apo B-E receptors, with cholesterol esters again being catabolized. However, once receptor mechanisms are overwhelmed, VLDL and LDL particles may accumulate, thus adding to the risk of developing atherosclerosis.40 Therefore, CETP activity may actually be atherogenic. For example, excess LDLs or modified LDLs may be taken up by arterial macrophages in hyperlipidemic individuals, resulting in formation of lesions and progression of atherosclerosis.41 In support of this, CETP activity is increased in diabetic humans and nonhuman primates, which results in modification of lipoprotein com-

![Figure 3](image-url)
position and particle number and may put diabetics at greater risk for development of atherosclerosis.6,33,43,44

By contrast, the first 2 routes of metabolism of cholesterol esters of HDLs in dogs and cats are predominantly via RCT because neither of these 2 species appears to have appreciable amounts of CETP activity in the circulation (Fig 3).33,35,43 In dogs, HDLs become enriched with cholesterol esters and apo E, forming unique HDL1 particles. Although similar to HDL1 particles, HDL1 particles are lighter with a hydrated density similar to that of human LDLs.46 Electrophoretic mobility of HDL1 particles is slower when compared to that of HDL2 and HDL3 fractions (ie, α2 vs α1). It is this HDL1 fraction that is increased whenever dogs are hypercholesterolemic. However, because there is little or no transfer of cholesterol esters to VLDLs or LDLs, atherogenic apo B-containing particles are not formed in dogs and cats.

Diagnostic Approach to Hyperlipemia and Hyperlipoproteinemia

Turbidity—Inspection of the extent of serum turbidity or lactorcenes provides a useful estimate of triglyceride concentrations. Normal straw-colored serum usually has a triglyceride concentration <200 mg/dL. Hazy serum contain approximately 300 mg/dL, whereas opaqueness is seen with triglyceride concentrations >600 mg/dL. Sera with turbidity similar to that of skim milk can have triglyceride concentrations as high as 1,000 mg/dL, whereas turbidity similar to that of whole milk can indicate concentrations of 2,500 to 4,000 mg/dL. Specific determinations of serum triglyceride concentrations are useful, especially when continued monitoring is needed or response to lipid-lowering treatments must be assessed. Increases in serum cholesterol concentrations alone do not generally impart turbidity to a serum sample without an increase in triglyceride concentrations.

Refrigeration test—The refrigeration test can be used without other more specific techniques and is conducted simply by leaving serum undisturbed in a refrigerator overnight. It can then be inspected for the existence of a cream-colored layer or ring at the top of the sample, which indicates a positive result for chylomicrons. When the underlying serum is reasonably clear, a presumption of pure hyperchylomicronemia is concluded. This finding is consistent with an animal that was allowed to eat up until the time of sample collection or the possibility of primary hyperchylomicronemia. When the underlying serum remains turbid with or without a cream-colored layer or ring, this is indicative of an excess of other lipoproteins. This finding is referred to as mixed hyperlipoproteinemia and usually includes VLDLs as well.

Interference of laboratory measurements by lipids—Hyperlipemia interferes with measurement of serum concentrations of direct bilirubin, resulting in moderate increases in the measured concentration of direct bilirubin. It will often decrease serum concentrations of cholesterol and chloride, serum amylase activity, and serum lipase activity and directly interfere with plasma protein and hemoglobin assays. An excessive amount of chylomicrons will displace water in a defined volume of sera, thereby falsely decreasing other serum components, especially electrolytes, as a result of a dilution effect. Hyperbilirubinemia will interfere with cholesterol determinations, resulting in lower cholesterol concentrations. Hypercholesterolemia may also decrease measured triglyceride concentrations.

The possibility that a serum sample could have been from an animal that was allowed access to food up until the time the sample was obtained should always be considered. For most animals, removal of food 8 to 10 hours prior to collection of a blood sample for submission to a laboratory is sufficient for general screening purposes. Animals that are hyperlipidemic after food is withheld for 12 hours prior to collection of a sample may have a primary lipid abnormality that warrants further investigation.

Evaluation of serum total cholesterol and triglyceride concentrations is helpful in initially evaluating lipid abnormalities. Use of frozen samples obtained from 9 dogs and 2 cats revealed high glycerol blanks determined as free glycerol concentrations. It is unknown whether this effect was attributable to freeze-thaw processing or autohydrolysis during storage conditions.

Techniques for analysis of lipoproteins—Electrophoresis of lipoproteins is a somewhat nonspecific technique, but it is useful when samples obtained before and after treatment are available. It is easily performed but requires access to scanning densitometry equipment for quantification. Precipitation techniques may become more applicable in the future as an increasing number of laboratories becomes familiar with these methods.5 Ultracentrifugation is usually not indicated, except in research or detailed clinical situations, and requires additional laboratory skills and equipment to be performed reliably. Secondary hyperlipidemias should be ruled out on the basis of results of other commonly performed laboratory tests so that an accurate diagnosis can be established.

It should be mentioned that major differences exist between circulating plasma lipoproteins of dogs and cats and those of humans. These differences can be most readily appreciated via densitometric evaluation of lipoproteins stained for evaluation of lipid content after agarose gel electrophoresis (Fig 4). Dogs and cats

Figure 4—Densitometric tracings of lipoproteins for various species after agarose gel electrophoresis. (Reproduced with permission from Bauer JE. Diet-induced alterations of lipoprotein metabolism. J Am Vet Med Assoc 1992;201:1691-1694.)
typically are HDL-predominant animals. They are more resistant to increases in LDL cholesterol concentrations and associated atherogenesis, compared to LDL-predominant species such as humans and nonhuman primates. Reasons for this intriguing difference are not completely understood but are of considerable interest to investigators.

Commercial laboratories that offer precipitation or electrophoretic techniques may analyze and interpret dog and cat sera on the basis of patterns for sera of humans. Relying on this approach is not advisable. Precipitation techniques used for human lipoprotein fractionation do not universally quantify canine HDL and LDL fractions. A precipitation technique has been published for quantitation of canine plasma lipoproteins but has not been widely adapted for routine use by veterinary clinical laboratories.

For these reasons, my laboratory prefers to use

Table 2—Primary and secondary disorders of lipid and lipoprotein metabolism in dogs and cats

<table>
<thead>
<tr>
<th>Species</th>
<th>Disorder</th>
<th>Serum lipid abnormalities</th>
<th>Lipoprotein alterations (mobility on agarose)</th>
<th>Other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td><strong>Primary disorders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Idiopathic hyperlipemia</td>
<td>Marked increase</td>
<td>Increase of chylomicrons (origin) or increase of a combination of chylomicrons and VLDLs (origin plus pre-β)</td>
<td>Risk of pancreatitis; may affect insulin resistance; and may affect fasting hyperinsulinemia</td>
</tr>
<tr>
<td></td>
<td>Hypercholesterolemia*</td>
<td>Moderate increase</td>
<td>HDL1 increase (α1)</td>
<td>Possible role in retinal pigment epithelial dystrophy</td>
</tr>
<tr>
<td></td>
<td>Secondary disorders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consumption of high-fat diets</td>
<td>Moderate increase</td>
<td>HDL1 increase (α1)</td>
<td>LCAT increase; for cholesterol concentration &gt; 750 mg/dL, there is a risk of atheroma</td>
</tr>
<tr>
<td></td>
<td>Pancreatitis</td>
<td>Increase in triglycerides</td>
<td>Increase of a combination of chylomicrons and VLDLs (origin plus pre-β)</td>
<td>Increased triglyceride concentrations; risk factor for pancreatitis</td>
</tr>
<tr>
<td></td>
<td>Hypothyroidism</td>
<td>Moderate increase</td>
<td>HDL1 increase (α1)</td>
<td>For cholesterol concentration &gt; 750 mg/dL, there is a risk of atheroma</td>
</tr>
<tr>
<td></td>
<td>Cholestasis</td>
<td>Moderate increase</td>
<td>HDL1 increase (α1)</td>
<td>Not determined</td>
</tr>
<tr>
<td></td>
<td>Hyperadrenocorticism</td>
<td>Mild increases in triglycerides and cholesterol</td>
<td>Increases in VLDLs (pre-β) and LDLs (β)</td>
<td>Excess corticosteroid may increase insulin resistance</td>
</tr>
<tr>
<td></td>
<td>Nephrotic syndrome</td>
<td>Mild increases in triglycerides and cholesterol</td>
<td>None reported</td>
<td>May be attributable to high-fat diets used in treatment of renal diseases</td>
</tr>
<tr>
<td>Cats†</td>
<td><strong>Primary disorders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inherited hyperchylomicronemia</td>
<td>Marked increase</td>
<td>Increase in chylomicrons (origin) or increase in VLDLs (origin plus pre-β) or increase in both</td>
<td>Decreased LPL activity (similar to type-I hyperlipoproteinemia in humans)</td>
</tr>
<tr>
<td></td>
<td>Hypercholesterolemia*</td>
<td>Moderate increase</td>
<td>Increase in LDLs (β)</td>
<td>Xanthomas (similar to type-Il a hyperlipoproteinemia in humans)</td>
</tr>
</tbody>
</table>

*Reported in Briard breed. †Secondary disorders in cats are poorly documented but generally similar to those seen in dogs. LCAT = Lecithin-cholesterol acyl transferase. LPL = Lipoprotein lipase. See Table 1 for remainder of key.
agarose gel electrophoresis to assess lipoprotein distributions. Overall, results for this technique may not be as quantitative as those for a carefully modified and validated precipitation technique. However, most human clinical laboratories can perform lipoprotein electrophoresis. With practice and in conjunction with reference ranges for humans established by each laboratory, electrophoreograms for dogs and cats can be readily interpreted. Reference ranges from my laboratory have been published.10

Disorders Associated with Lipid or Lipoprotein Abnormalities in Dogs and Cats

Primary and secondary hyperlipidemias of dogs and cats have been reviewed elsewhere.48,49 The most common primary lipid abnormality is fasting hypertriglyceridemia, which appears to be familial in breeds such as Miniature Schnauzers and Beagles. However, other breeds may also be affected. Main features of the primary and secondary lipid or lipoprotein abnormalities have been summarized (Table 2). It should be mentioned that hypercholesterolemia in dogs, regardless of cause, is associated with increases in HDL₃ fractions. Also, in some secondary disorders, such as pancreatitis, hyperadrenocorticism, and nephrotic syndrome, increases of VLDL-associated triglycerides are also seen. Generally, these serum lipid concentrations are only mildly or moderately increased. Although hypertriglyceridemias may predispose dogs to the development of pancreatitis, the moderate hypercholesterolemias seem do not appear to be a known health risk in this species. In cats, there are two primary disorders of lipid metabolism, but these are rare. Disorders of cats in which there are secondary plasma lipoprotein alterations include diabetes mellitus and the nephrotic syndrome. Drug-induced hyperlipidemias may also be seen in cats, such as those with megestrol acetate-induced diabetes mellitus. Generally, lipoprotein alterations appear to be similar to those seen secondarily in dogs, although unrecognized differences likely exist.

Finally, it is interesting that many of the dyslipoproteinemias seen in dogs and cats appear to be similar to those observed in humans, including those seen with consumption of high-fat diets, hypothyroidism, diabetes mellitus, and pancreatitis. However, differences in cholesterol transport among the companion animal species relating to RCT and CETP are such that dogs and cats are spared the risk of atherogenesis and coronary artery disease described in humans. Nonetheless, similarities in lipid metabolism of dogs and cats may provide a useful source of new information on these disorders in all species by virtue of studies designed to better understand these naturally developing diseases.

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