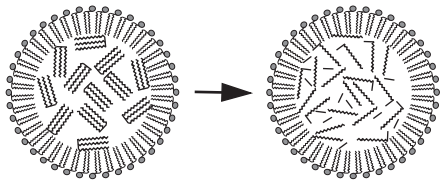
Lipid Digestion

An Introduction to

Lipid Transport and Digestion

with consideration of

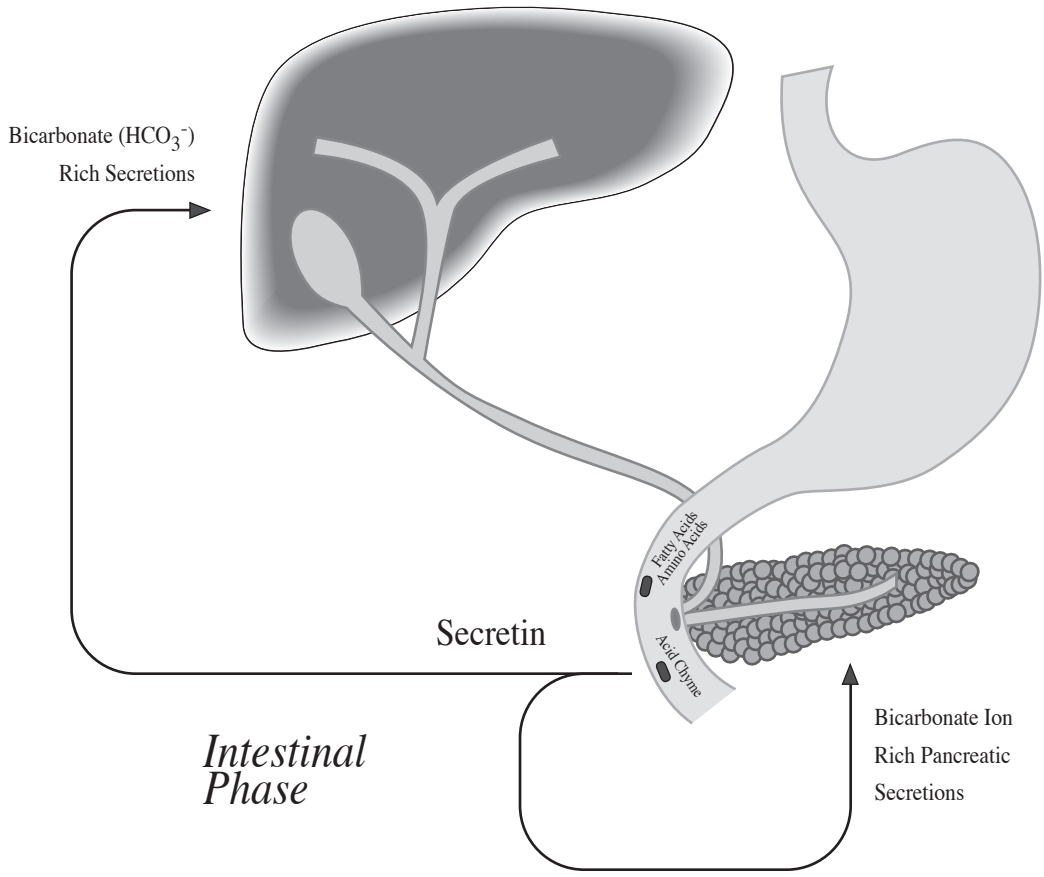
High Density and Low Density Lipoproteins



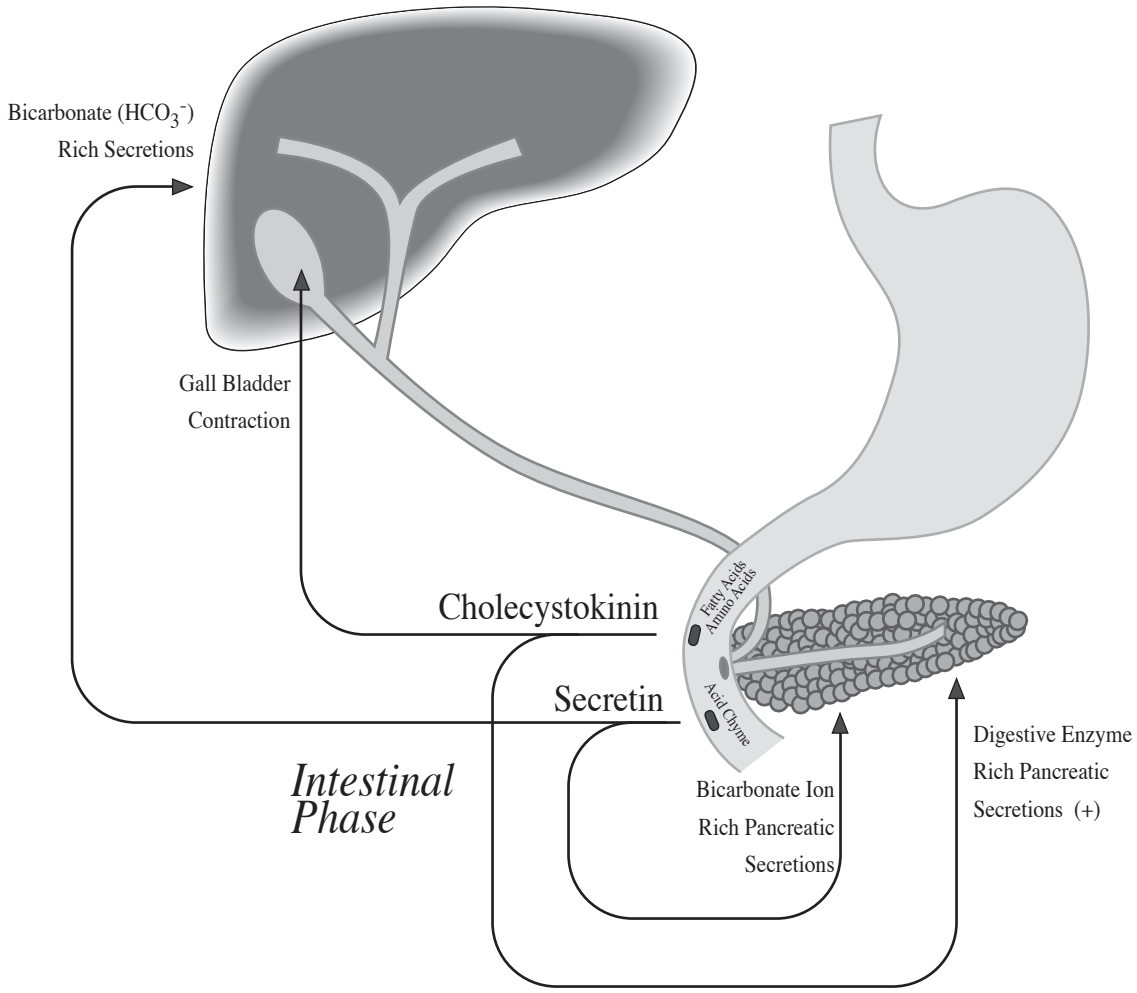
By Noel Ways

Boli containing lipids enters the stomach lumen where stomach churning mechanically breaks the boli down and mixes them with gastric juices forming chyme. Here, the lipids are in suspension within the watery chyme; and without continued churning, the lipids and water would separate (as does an oil and vinegar dressing). As the stomach begins to incrementally empty, the nutrient rich acidic chyme enters into the duodenum where the lipids may be "formally" processed.

Processing of the lipids by the digestive system begins with a two-pronged approach. First, acid rich chyme triggers the release of secretin from intestinal enteroendocrine cells of the duodenum. Secretin signals both the liver and the pancreas to secrete a bicarbonate rich secretion the function of which is to neutralize the acid. The neutralization is important so that a thick protective lining of mucous is not necessary as this would impede nutrient absorption.



Secondly, the presence of nutrients within the duodenum, such as lipids, triggers the secretion of cholecystokinin into the blood stream. Cholecystokinin will have two effects. First, the gall bladder contracts (and the hepatopancreatic ampulla relaxes) allowing bile to flow into the lumen of the duodenum. The purpose of the bile contents is to emulsify the lipids.

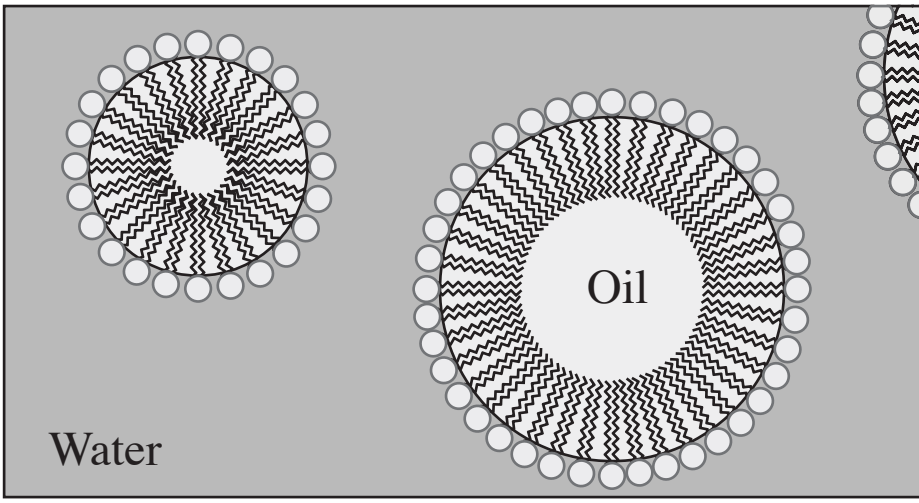


The second function of cholecystokinin is to stimulate the pancreas to secrete digestive enzymes, of which pancreatic lipase is of particular importance for this discussion.

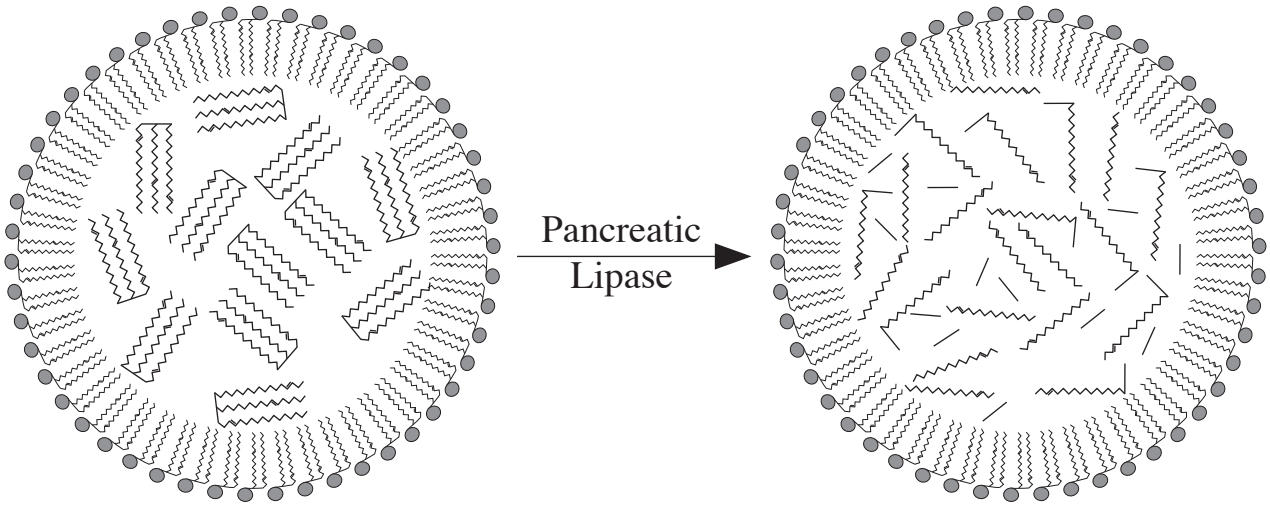
Within the bile there are two important emulsifiers. Lecithins, which are essentially a slightly modified phospholipids with hydrophobic fatty acid tails and a charged heads of phosphate and choline; and bile acids that contain a hydrophobic steroid "tail", and a charged "head". In both cases, these emulsifiers will break apart masses of lipids into small droplets by inserting the hydrophobic end into the lipid and the hydrophilic head will then face the watery outside. Here the phospholipids are forming a "bridge" between the water and the lipid, and in a sense, the lipid droplet "behaves" as a salt in that the water "sees" and reacts with the charged heads.

Hydrophobic Tail

Hydrophilic Head



Emulsifiers break up the mass of lipids into micelles in order to suspend the lipids within a watery environment. But beyond that, and perhaps more importantly, the emulsification process also dramatically increases the digestive surface area of the lipids. Now, pancreatic lipase has quick and easy access to the lipids and can therefore quickly digest them.

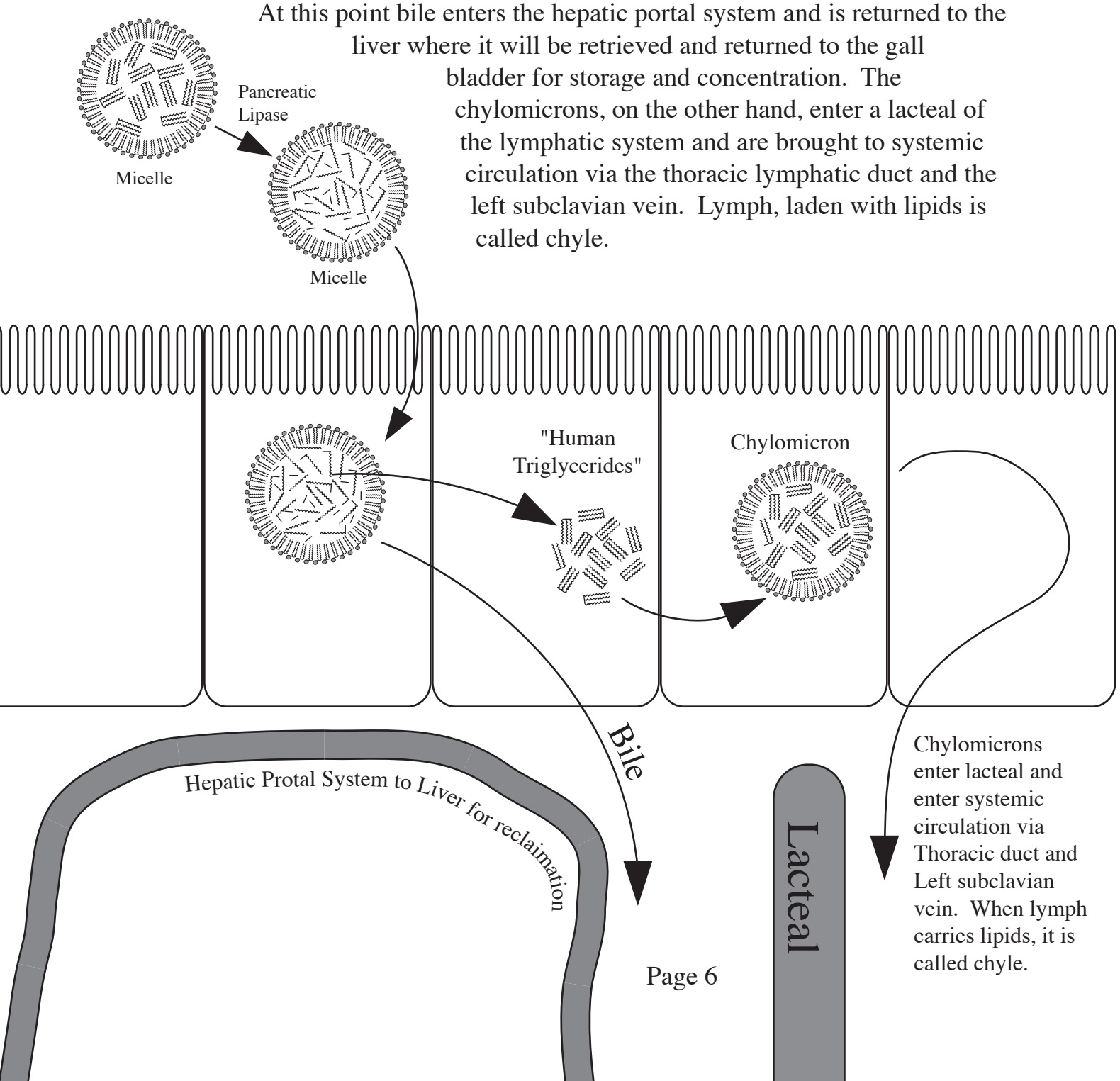


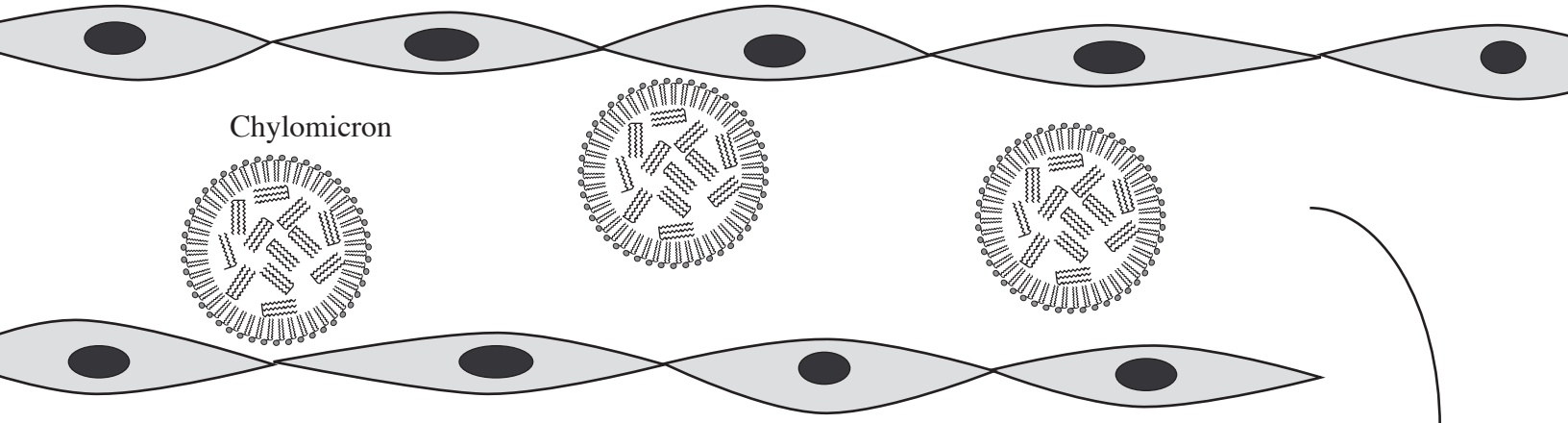
The effect of pancreatic lipase is to break the triglycerides into monoglycerides, free fatty acids, and glycerol. Once this operation is complete the micelle may then be absorbed into the columnar cells of the intestine.

It is an intriguing fact that whenever lipids have to cross a membrane, this process of break-down and build-up will always occur.

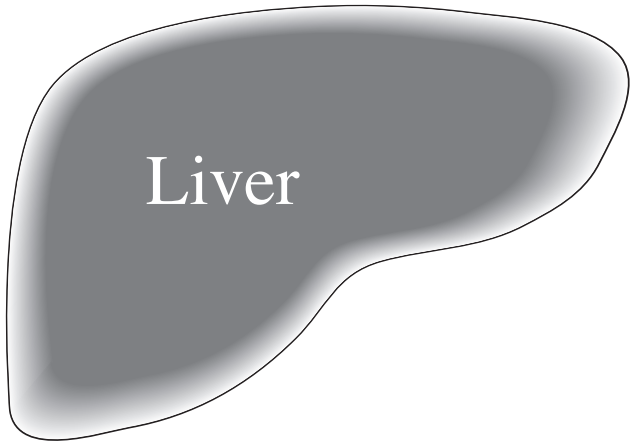
With the contents of the micelles broken down, the micelle is absorbed into the columnar cells of the intestinal mucosa. Within the columnar cells the micelle assembly will be broken down in such a manor that the lipid components enter cellular organelles (smooth endoplasmic reticulum) where they are re-synthesized into "human triglycerides", and then emulsified with lipoproteins. Lipoproteins, like lecithin and bile, are emulsifiers by virtue of the presence of both hydrophilic and hydrophobic ends and can create a "bridge" between the lipids and water. This structure is called a chylomicron.

At this point bile enters the hepatic portal system and is returned to the liver where it will be retrieved and returned to the gall bladder for storage and concentration. The chylomicrons, on the other hand, enter a lacteal of the lymphatic system and are brought to systemic circulation via the thoracic lymphatic duct and the left subclavian vein. Lymph, laden with lipids is called chyle.





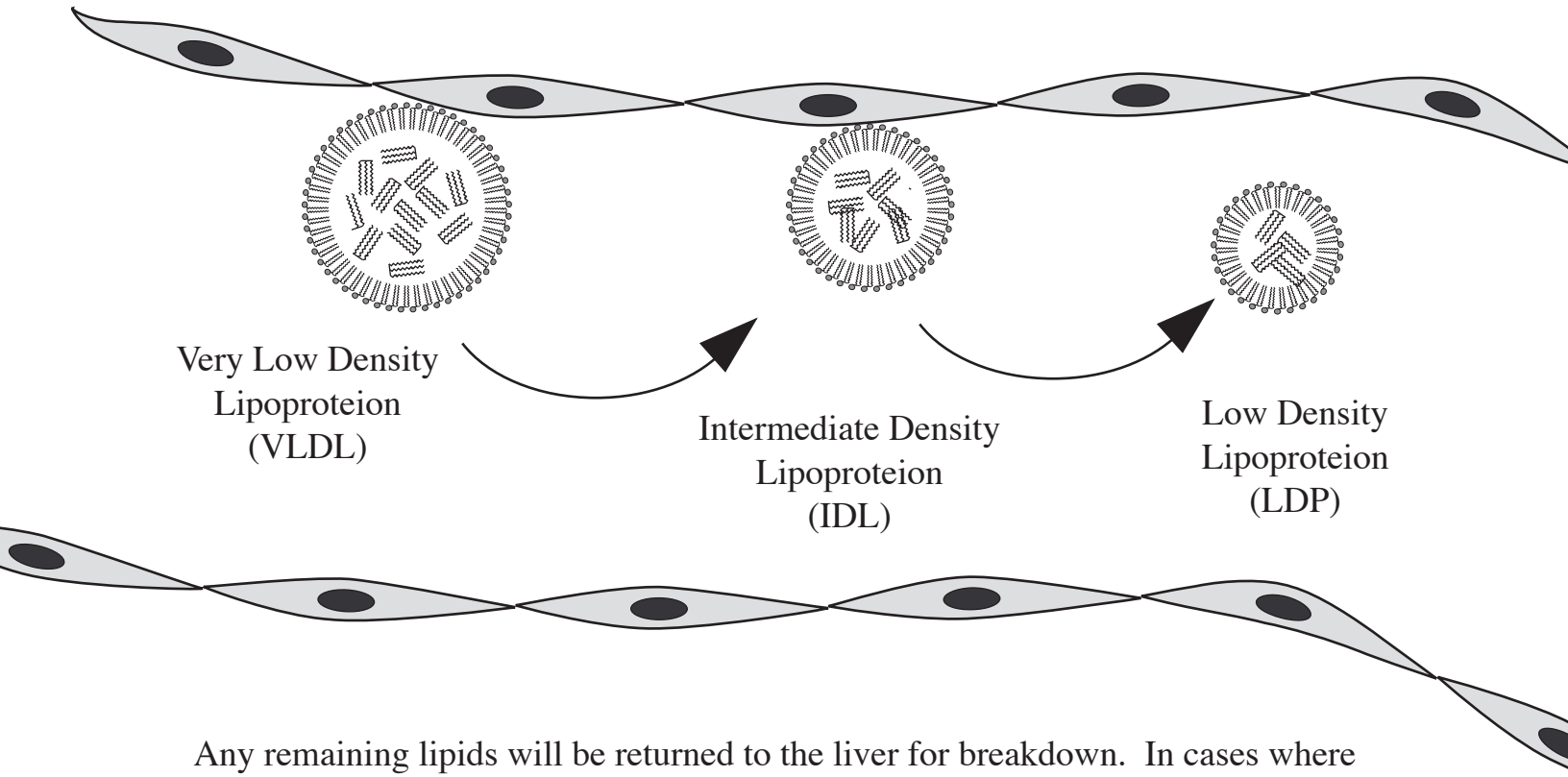
As the chylomicrons proceed through the circulatory system, they "feed" triglycerides to endothelial cells according to their needs. More specifically, tissues that require lipids will produce enzymes on endothelial cells that will trigger the release of lipids from the chylomicron to the cells that require them.



Whatever lipids are not used in this manor, the chylomicron with remaining contents will be absorbed back into the liver and broken down.

The Liver may be considered the "grand central station" of lipid metabolism; which will include the production of cholesterol, and such lipid based compounds as phospholipids, and bile salts. The liver will also store such lipid soluble vitamins as A, D, E, and K. And when body tissues are in need of any such components or substances, it is the liver the will have to manage to make or procure them, and then package them for transport within the water based blood. As with the chylomicrons, the liver will use lipoproteins for emulsification.

Lipids are generally of lower density than water and therefore tend to float above water if allowed to do so. With this in mind, when the liver emulsifies newly synthesized lipids, the structure tends to be of very low density due to the preponderance of lipids within. As such, the structure is called a "Very Low Density Lipoprotein (VLDP). The VLDP is released into the blood stream and nourishes body tissues according to their needs. As this process proceeds the lipid storage vehicle will have less and less lipids, and therefore will become higher in density. The structure is now renamed as an "Intermediate Density Lipoprotein (IDLP). The feeding process continues, and the structure increases in density. It is again renamed as a "Low Density Lipoprotein (LDL)". These structures are designed to deliver lipid products to the cells.



Any remaining lipids will be returned to the liver for breakdown. In cases where LDL is excessive or can not be readily reabsorbed, the structures may become damaged (oxidized) and contribute to plaque buildup in arteries. This, of course, may contribute to the development of and/or worsening of a heart disease condtion.

The means by which the LDL returns to the heart is often by being absorbed by HDL.

Where as the low density lipoproteins are the means by which the liver transports lipid products to the tissues, the liver will likewise produce an another distinct structure to retrieve unneeded lipids from tissue sources and bring them back to the liver for breakdown. This structure consists of lipoproteins, but with very little lipids within. In other words, it has a capacity to enlarge as lipids are absorbed. Due to the lack of low dense lipids, the structure is relatively high in density, and is therefore called, "High Density Lipoproteins (HDL)".

The HDL leaves the liver, picks up lipids from cells and tissues where the lipids are no longer needed, as well as LDL in the blood stream, and brings them back to the liver for breakdown.