4.5: Understanding Blood Cholesterol

Skills to Develop

- Compare and contrast the roles of LDLs and HDLs in your body.
- Explain the purpose of a blood lipid profile and identify healthy ranges.

You may have heard of the abbreviations LDL and HDL with respect to heart health. These abbreviations refer to low-density lipoprotein (LDL) and high-density lipoprotein (HDL), respectively. Lipoproteins are characterized by size, density, and composition. As the size of the lipoprotein increases, the density decreases. This means that HDL is smaller than LDL. Why are they referred to as “good” and “bad” cholesterol? What should you know about these lipoproteins? This section will help you answer these questions.

Short chain fatty acids and medium chain fatty acids can be carried in the bloodstream attached to the protein, albumin. Long chain fatty acids are much less water soluble so require special transport within lipoproteins. After a meal, during digestion and absorption, long chain fatty acids are packaged into chylomicrons and transported throughout the body in these micelles.

Cholesterol is found only in animal products. Also, our body makes cholesterol because it is important for the synthesis of bile and hormones. The amount of cholesterol synthesized is related to the amount found in the blood. This is also influenced by the amount of cholesterol in your diet.

Major Lipoproteins

Recall that chylomicrons are transporters of fats throughout the watery environment within the body. After about ten hours of circulating throughout the body, chylomicrons gradually release their triacylglycerols into cells until all that is left
of their composition is cholesterol-rich remnants. These remnants are used as raw materials by the liver to formulate specific lipoproteins. Following is a list of the various lipoproteins and their functions:

- **VLDLs.** Very low-density lipoproteins are made in the liver from remnants of chylomicrons and transport triacylglycerols from the liver to various tissues in the body. As the VLDLs travel through the circulatory system, the lipoprotein lipase strips the VLDL of triacylglycerols. As triacylglycerol removal persists, the VLDLs become intermediate-density lipoproteins.

- **IDLs.** Intermediate-density lipoproteins transport a variety of fats and cholesterol in the bloodstream and are a little under half triacylglycerol in composition. While traveling in the bloodstream, cholesterol is gained from other lipoproteins while circulating enzymes strip its phospholipid component. When IDLs return to the liver, they are transformed into low-density lipoprotein.

- **LDLs.** As low-density lipoproteins are commonly known as the “bad cholesterol” it is imperative that we understand their function in the body so as to make healthy dietary and lifestyle choices. LDLs carry cholesterol and other lipids. They are comprised of very small amounts of triacylglycerols, and house over 50 percent cholesterol and cholesterol esters. LDL is developing as the lipid is removed from VLDL by the body's cells. How does the body receive the lipids contained therein? As the LDLs deliver cholesterol and other lipids to the cells, each cell’s surface has receptor systems specifically designed to bind with LDLs. Circulating LDLs in the bloodstream bind to these LDL receptors and are consumed. Once inside the cell, the LDL is taken apart and its cholesterol is released. In liver cells these receptor systems aid in controlling blood cholesterol levels as they bind the LDLs. A deficiency of these LDL binding mechanisms will leave a high quantity of cholesterol traveling in the bloodstream, which can lead to heart disease or atherosclerosis. Diets rich in saturated fats will prohibit the LDL receptors. Thus, LDL receptors are critical for regulating cholesterol levels.

- **HDLs.** High-density lipoproteins are responsible for carrying cholesterol out of the bloodstream and into the liver, where it is either reused or removed from the body with bile. HDLs have a very large protein composition coupled with low cholesterol content (20 to 30 percent) compared to the other lipoproteins. Hence, these high-density lipoproteins are commonly called “good cholesterol.”
Contrasting LDL and HDL

Heart attack and atherosclerosis are conditions often caused by cholesterol that has accumulated and thickened in the walls of arteries. HDLs and LDLs are directly connected to these life-threatening ailments. By comparing and contrasting the roles each of these lipoproteins serves in the health of heart and blood vessels, you will be able to construct and evaluate a plan of action for your personal health. Consider the following lipoprotein facts:

- **LDL/HDL composition.** LDL is approximately 25 percent protein and 75 percent cholesterol and other fats. LDL is bigger (yet lighter) and richer in cholesterol than HDL. HDL is 50 percent protein and 50 percent cholesterol and other fats. HDL is smaller, more dense, and richer in protein.

- **LDL/HDL function.** LDLs carry cholesterol into cells for normal usage, but LDLs can also deposit cholesterol into the walls of blood vessels, which can lead to harmful disease. HDLs scavenge excess cholesterol from the cells, tissues, and blood vessels and deliver these back to the liver, where these are either reused or excreted.

- **LDL/HDL and inflammation.** LDLs carry lipids that are proinflammatory and may contribute to heart disease. HDLs transport lipids that are anti-inflammatory and may reduce the occurrence of heart disease.

- **LDL/HDL warnings.** High LDL values warn of increased health risks for heart disease, while high HDL values indicate a reduced risk for heart disease.
• **Oxidized LDL.** LDLs become more dangerous when oxidized. Oxidation is defined as the loss of electrons between two substances via a chemical reaction. If an LDL oxidation occurs, the oxidized LDL is left unstable. Oxidized LDL can speed up the process of plaque formation in the arteries. It is believed to hasten the deposition of cholesterol into the arterial walls and to induce a chronic inflammatory effect throughout the body's vast network of vessels. This activity promotes atherosclerosis and significantly increases risks for heart attack or stroke.

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**Blood Cholesterol Recommendations**

For healthy total blood cholesterol, the desired range you would want to maintain is under 200 mg/dL. More specifically, when looking at individual lipid profiles, a low amount of LDL and a high amount of HDL prevents excess buildup of cholesterol in the arteries and wards off potential health hazards. An LDL level of less than 100 milligrams per deciliter is ideal while an LDL level above 160 milligrams per deciliter would be considered high. In contrast, a low value of HDL is a telltale sign that a person is living with major risks for disease. Values of less than 40 milligrams per deciliter for men and 50 milligrams per deciliter for women mark a risk factor for developing heart disease. In short, elevated LDL blood lipid profiles indicate an increased risk of heart attack, while elevated HDL blood lipid profiles indicate a reduced risk. An excellent resource for more information is the following guide from the National Cholesterol Education Program: [ATP III Guidelines At-A-Glance Quick Desk Reference - National Heart, Lung, and Blood Institute](http://www.cdc.gov/nchs/fastats/lcod.htm)

The University of Maryland Medical Center reports that omega-3 fatty acids promote lower total cholesterol and lower triacylglycerols in people with high cholesterol. University of Maryland Medical Center. "Omega-3 fatty acids." [http://www.umm.edu/altmed/articles/omega-3-000316.htm](http://www.umm.edu/altmed/articles/omega-3-000316.htm) It is suggested that people consume omega-3 fatty acids such as alpha-linolenic acid in their diets regularly. Polyunsaturated fatty acids are especially beneficial to consume because they both lower LDL and elevate HDL, thus contributing to healthy blood cholesterol levels. The study also reveals that saturated and trans fatty acids serve as catalysts for the increase of LDL cholesterol. Additionally, trans fatty acids lower HDL levels, which can impact negatively on total blood cholesterol.

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**Cardiovascular Disease**

According to the Centers for Disease Control and Prevention (CDC), heart disease is the leading cause of death in the United States (Centers for Disease Control and Prevention. "Leading Causes of Death." Last updated September 6, 2011. [http://www.cdc.gov/nchs/fastats/lcod.htm](http://www.cdc.gov/nchs/fastats/lcod.htm)). The disease generally starts with arteriosclerosis, or a thickening, loss of elasticity, and calcification of the arterial walls. Atherosclerosis is a type of arteriosclerosis often defined as a "hardening of the arteries." It is a chronic condition so common that most people show signs of it by the time they turn thirty. Arteries start to narrow and harden when fats accumulate along their inner walls and form plaques. A plaque is made of fat, cholesterol, calcium, and other substances found in blood.
Figure 4.5.2: Illustration comparing a normal blood vessel and partially blocked vessel due to atherosclerotic plaque build-up. Plaque formation along arterial walls impedes blood flow and can create a thrombus, or stationary blood clot. Image used with permission from BruceBlaus (via Wikipedia). For a video of the process click here.

Plaque formation causes arteries to narrow and harden, which elevates blood pressure because the vessels can’t expand effectively to accommodate blood pulses. Higher blood pressure strains the heart and causes more damage. Arterial walls can become so weakened due to high blood pressure that they balloon and form what is known as an aneurysm. If the aneurysm bursts, it becomes a life-threatening event. The plaques themselves can also rupture due to a spike in blood pressure or a tremor along an arterial wall, and the body responds to this perceived injury by forming blood clots. These clots are serious health threats, whether they are stationary (a thrombus) or moving (an embolus). A stable clot can slowly kill off surrounding tissue by restricting oxygen (called ischemia) to the area, or grow so big that it blocks blood circulation and causes thrombosis. When a moving clot becomes stuck in an artery too small for its passage, it cuts off blood flow and causes cell death. This is referred to as an embolism. Blood clots in heart and brain arteries can cause heart attacks or strokes, respectively.

Table 4.5.1: The Risk Factors for Cardiovascular Disease

<table>
<thead>
<tr>
<th>Unmodifiable Risk Factors</th>
<th>Modifiable Risk Factors</th>
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<tbody>
<tr>
<td><strong>Age.</strong> Risk increases for men at forty-five, and for women at fifty-five.</td>
<td><strong>Cigarette smoking.</strong> Nicotine constricts blood vessels, and carbon monoxide damages their inner lining, which increases the risk of atherosclerosis.</td>
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<td><strong>Sex.</strong> Men have a higher risk than women, though the risk for women steeply rises after menopause.</td>
<td><strong>Obesity.</strong> Excess weight worsens other risk factors.</td>
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<td><strong>Family history.</strong> The more family members who have heart disease, the greater the risk.</td>
<td><strong>Diabetes.</strong> This condition is associated with an increased risk of heart disease. Both types have certain risk factors in common, including obesity and...</td>
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### Unmodifiable Risk Factors

- High blood pressure.
- **Physical inactivity.** Lack of exercise is associated with heart disease.
- **Cholesterol levels.** High levels of blood cholesterol can increase the risk. A high level of low-density lipoprotein (LDL), or the “bad” cholesterol, is a common contributing factor. However, a low level of high-density lipoprotein (HDL), or “good” cholesterol, can also promote atherosclerosis.
- **Stress.** Excess stress is a risk factor for heart disease.
- **Hypertension.** High blood pressure left untreated can cause heart disease.

### Modifiable Risk Factors

Diet and nutrition can play a significant role in reducing the risk of cardiovascular disease. It is helpful to lower sodium intake, increase consumption of dietary fiber, and limit consumption of saturated fat which promotes plaque formation. In addition, it is important to replace refined starches and added sugar, which can boost triglycerides, with whole grains, fruits, and vegetables. Eating foods rich in omega-3 fatty acids, especially fish, using alcohol in moderation, and opting for low or no-fat dairy products can all help reduce your cardiovascular disease risk. Emphasizing vegetable-based sources of protein, such as beans and legumes, can be beneficial, as well as consuming more soy products. It is also important to maintain a healthy weight, manage cholesterol levels, and avoid smoking or chewing tobacco.

Your total fat intake should be less than 35% of your total energy intake and that fat should be distributed 1/3 saturated, 1/3 monounsaturated, and 1/3 polyunsaturated fat. Here are suggestions on ways to reduce your saturated fat intake: 1) reduce your animal fat intake by selecting lean cuts of meat, trimming the fat, removing the skin and/or baking and broiling instead of frying; 2) drink fat-free or 1% milk, and 3) reduce your intake of coconut and palm oils which are rich in saturated fat. You will find these fats in commercial baked goods. Also, replace your saturated fat intake with monounsaturated fat such as canola oil, olive oil and/or nuts. Polyunsaturated fats should comprise 1/3 of your dietary fat intake. You find these fats in vegetable oil and fish oil. Finally, reduce your intake of trans fatty acids which are found in hydrogenated or partially hydrogenated vegetable oil, deep fried foods, hard margarine and commercial baked goods.
Tools for Change

Being conscious of the need to reduce cholesterol means limiting the consumption of saturated fats and trans fats. Remember that saturated fats found in some meat, whole-fat dairy products, and tropical oils elevate your total cholesterol. Trans fats, such as the ones often found in margarines, processed cookies, pastries, crackers, fried foods, and snack foods also elevate your cholesterol levels. Read and select from the following suggestions as you plan ahead:

Soluble fiber reduces cholesterol absorption in the bloodstream. Try eating more oatmeal, oat bran, kidney beans, apples, pears, citrus fruits, barley, and prunes.

Fatty fish are heart-healthy due to high levels of omega-3 fatty acids that reduce inflammation and lower cholesterol levels. Consume mackerel, lake trout, herring, sardines, tuna, salmon, and halibut. Grilling or baking is best to avoid unhealthy trans fats that could be added from frying oil.

Walnuts, almonds, peanuts, hazelnuts, pecans, some pine nuts, and pistachios all contain high levels of unsaturated fatty acids that aid in lowering LDL. Make sure the nuts are raw and unsalted. Avoid sugary or salty nuts. One ounce each day is a good amount.

Olive oil contains a strong mix of antioxidants and monounsaturated fat, and may lower LDL while leaving HDL intact. Two tablespoons per day in place of less healthy saturated fats may contribute to these heart-healthy effects without adding extra calories. Extra virgin olive oil promises a greater effect, as the oil is minimally processed and contains more heart-healthy antioxidants.

Testing Your Lipid Profile

The danger of consuming foods rich in cholesterol and saturated and trans fats cannot be overemphasized. Regular testing can provide the foreknowledge necessary to take action to help prevent any life-threatening events.

Current guidelines recommend testing for anyone over age twenty. If there is a family history of high cholesterol, your healthcare provider may suggest a test sooner than this. Testing calls for a blood sample to be drawn after nine to twelve hours of fasting for an accurate reading. (By this time, most of the fats ingested from the previous meal have circulated through the body and the concentration of lipoproteins in the blood will have stabilized.)

According to the National Institutes of Health (NIH), the following total cholesterol values are used to target treatment:

- Desirable. Under 200 milligrams per deciliter
- Borderline high. 200–239 milligrams per deciliter
- High risk. 240 milligrams per deciliter and up

According to the NIH, the following desired values are used to measure an overall lipid profile:

- Desirable. Under 200 milligrams per deciliter
- Borderline high. 200–239 milligrams per deciliter
- High risk. 240 milligrams per deciliter and up
- LDL. Less than 160 milligrams per deciliter (if you have heart disease or diabetes, less than 100 milligrams per deciliter)
- HDL. Greater than 40–60 milligrams per deciliter
- Triacylglycerols. 10–150 milligrams per deciliter
- VLDL. 2–38 milligrams per deciliter

**Video 4.5.1: Understanding Cholesterol** ([https://www.youtube.com/v/hjv5OnbcjE8](https://www.youtube.com/v/hjv5OnbcjE8))

**Key Takeaways**

- Some of the major lipoproteins are VLDL, IDL, LDL, and HDL.
- VLDL delivers triacylglycerols and other lipids to the body’s tissues and slowly becomes IDL. The liver uses IDL to create LDL, the main transporter of cholesterol.
- LDL, or “bad” cholesterol, has low protein composition and high cholesterol content. High levels of LDL have been shown to increase the risks for heart disease.
- HDL or “good” cholesterol has a larger proportion of protein and a small cholesterol composition. HDL scavenges excess cholesterol and returns it to the liver for reuse or disposal. A high level of HDL reduces the risk for heart disease.
- It is important to maintain a healthy lipid profile with values as recommended by the NIH in order to minimize the risk of heart disease. Consuming omega-3 fatty acids can help maintain a healthy blood lipid profile.

**Discussion Starters**

1. Summarize the roles of LDL and HDL. Explain why LDL is termed “bad” cholesterol and why HDL is termed “good”
cholesterol.
2. Explain oxidation and how it affects LDL and contributes to heart disease.
3. Describe the procedure and blood test for testing your lipid profile.
4. Recall the desired lipid values set out by the NIH. Identify the desired total cholesterol, LDL, HDL, VLDL, and triacylglycerol values.
5. How has learning this information affected your motivation to eat a more healthy diet?