CHOLESTEROL & YOUR HEALTH

Summary

Cholesterol is a waxy fat that is present in all human beings. Two sources contribute to the amount of cholesterol in the human body. First, the liver manufactures about 80 percent of it. Second, people consume it by eating animal products such as meat, eggs and dairy products. Cholesterol is carried through the bloodstream by certain proteins (*apolipoproteins*). When these proteins wrap around cholesterol and other types of fats (**lipids**) to transport them through the bloodstream, the resulting "packages" are called **lipoproteins**. There are four different types of lipoproteins that carry cholesterol through the bloodstream:

- **High-density lipoproteins** (HDL), which are associated with "good" cholesterol.

- **Low-density lipoproteins (LDL), which are associated with "bad" cholesterol.**

- **Very-low-density lipoproteins** (VLDL), which are associated with "very bad" cholesterol.

- *Chylomicrons*, which only carry a small percentage of cholesterol. Chylomicrons are mostly rich in another type of fat (lipid) called **triglycerides**.
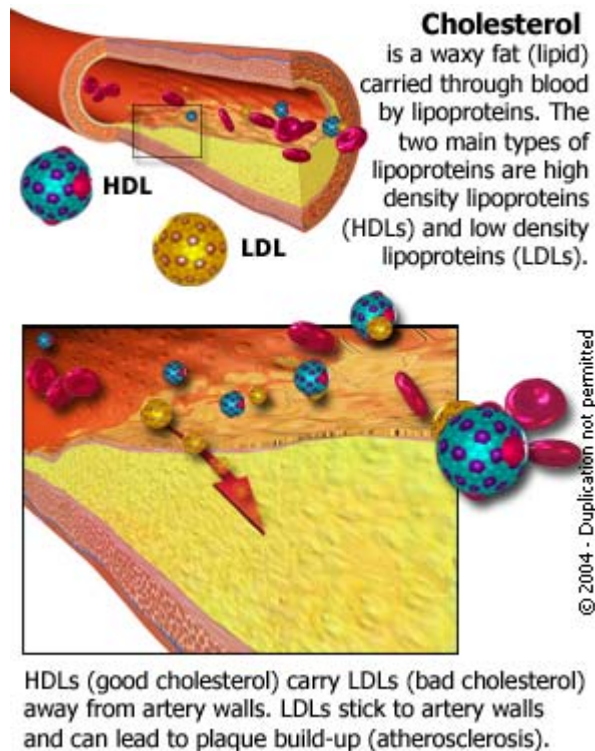
High levels of LDL cholesterol have been associated with hardened arteries (**atherosclerosis**) and **coronary artery disease**. In contrast, high levels of HDL cholesterol have been shown to reduce some of the harmful effects of LDL cholesterol. The **National Cholesterol Education Program** classifies cholesterol levels as follows (all measurements are in milligrams per deciliter):

- Total cholesterol levels less than 200 are desirable.

- Total cholesterol levels between 200 and 239 are borderline-high.

- Total cholesterol levels that are 240 or higher are high.

- HDL levels should be 40 or above (the American College of Cardiology recommends levels of 45 or above for women).

- LDL levels should *optimally* be less than 100 (levels greater than 129 are considered borderline-high, and levels greater than 159 are considered high).

About cholesterol

Cholesterol is a fat-like substance (**lipid**). It is both produced in the liver and consumed by eating animal products such as meat, eggs or dairy products. The body needs cholesterol, and manufactures all the cholesterol needed by various organ systems. In fact, the body naturally produces up to four times more cholesterol than what normally would be taken in through diet. The body uses cholesterol to:

- Assist in the manufacture of hormones or vitamin D
- Break down **carbohydrates** and **proteins**
- Help form a protective coating around nerves
- Build cell walls and to produce bile (the word *cholesterol* is Greek for "bile solids")

Cholesterol is a waxy fat (lipid) carried through blood by lipoproteins. The two main types of lipoproteins are high density lipoproteins (HDLs) and low density lipoproteins (LDLs).

HDL

LDL

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HDLs (good cholesterol) carry LDLs (bad cholesterol) away from artery walls. LDLs stick to artery walls and can lead to plaque build-up (atherosclerosis).

Cholesterol is carried through the bloodstream by **lipoproteins**. Lipoproteins are proteins that wrap around both cholesterol and other fatty materials and transport them through the bloodstream.

Two types of lipoproteins carry most of the cholesterol in the bloodstream, and they behave very differently as they move through the body:

- **High-density lipoproteins** (HDL). "Good" cholesterol, HDLs move easily through the blood and are actually beneficial to the body. They are stable and do not stick to **artery** walls. They help to prevent **heart disease** by carrying cholesterol away from the arteries and back to the liver, where the process of its removal from the body begins. Liver damage, from **alcohol** abuse or other conditions, can undo the beneficial effects of HDLs.

- **Low-density lipoproteins** (LDL). "Bad" cholesterol, LDLs contain more fat and less protein than HDLs. LDLs are unstable; they tend to fall apart. Rather than being removed from the body by the liver, they stick to (and can damage) cells lining the inside of artery walls. Areas of cell damage provide a magnet-like attraction for other fatty substances (e.g., **triglycerides**), sticky blood-clotting materials (e.g., fibrin and **platelets**) and white blood cells. The waxy accumulation of these materials is known as **plaque**. This can eventually lead to hardened arteries (**atherosclerosis**) or **coronary artery disease**. Therefore, high levels of LDLs are strongly associated with increased risk for heart disease. Many people with high levels of "bad" cholesterol also have high triglyceride levels because both types of fats have similar **risk factors** (e.g., **obesity** and **diabetes**).

Beyond these two main lipoproteins, researchers have identified a number of others that affect blood cholesterol. One of these is **very low-density lipoproteins** (VLDL), which is a very bad form of cholesterol. VLDLs and so-called **intermediate-density lipoproteins** (IDLs) belong to a newer category known as **non-HDL cholesterol**.

Studies are showing that high non-HDLs can raise the risk of non-fatal **heart attack** and **angina** among individuals who already have heart disease. Another type of lipoprotein is called **chylomicrons**, which are rich in triglycerides.

Finally, advances in research techniques have allowed for more precise measurements of various blood lipids, although the meaning of these new measurements is still under debate in the medical community. Lipoprotein "a" – abbreviated Lp(a) – is a type of cholesterol that is associated with increased risk of heart disease when values are greater than approximately 30 milligrams per deciliter. Lp(a) can sometimes be detected in patients with premature coronary heart disease, which is defined as heart disease that appears in men who are younger than 55 years old and women who are younger than 65 years old.

A second blood lipid known as *apolipoprotein B* (apo-B) may be helpful in determining cardiovascular risk. According to some studies, apo-B may even be a better predictor that LDL cholesterol. It may also be a good way to determine whether or not cholesterol-lowering drugs are working.

Researchers are also finding that genes involved in the size of cholesterol particles may be associated with human longevity. Studies have uncovered a specific gene that is involved in the size of lipoproteins. Results of these studies suggest that lipoprotein size can be inherited, and that larger sized lipoproteins may be associated with living to very old age.

About high cholesterol

The cholesterol value in the human body can rise to abnormally high levels when someone eats a **diet** high in **saturated fats** or **trans fats** – especially when that person is **obese** and/or rarely **exercises** (even moderate exercise has a heart-healthy effect). High cholesterol levels are dangerous because they are linked directly to **coronary artery disease** and hardening of the arteries (**atherosclerosis**). Abnormal cholesterol levels have also been linked to the risk of **heart attack**. Researchers have developed guidelines to help patients understand their risk of heart attack. These guidelines are based on known **risk factors**, such as smoking, diets high in fat, and obesity.

Optimum cholesterol levels are different for different people, depending on how many of these risk factors they have. It is recommended that people at high risk for heart attack aim for a lower cholesterol level than healthy people or people at moderate risk. (See **LDL and high risk patients**).

Studies have shown that cholesterol levels are linked to dietary fat. In particular, trans fats are especially dangerous. Trans fats not only increase levels of "bad" **LDL** cholesterol, but also decrease "good" **HDL** levels. This is especially worrisome, because trans fats (which prolong the shelf life of processed foods) are common ingredients in potato chips and other snack foods, many types of margarine and shortening, and deep fried and fast foods. In 2003, the U.S. Food and Drug Administration announced that processed foods will be required to list trans fatty acid levels by Jan. 1, 2006. This will be in addition to other nutritional information on their labels.

High cholesterol levels can also be caused by a number of different genetic conditions. The most widespread inherited cholesterol disorder is **familial hypercholesterolemia** (FH). The cholesterol levels of people with this disorder may reach as high as 550 milligrams per deciliter – almost four times the level considered desirable for the average person. With cholesterol this high, people with FH are at a high risk for an early heart attack, regardless of the presence of other risk factors. If FH is suspected, children as young as two years of age may be appropriate for a **cholesterol screening**.

Another genetic condition associated with high cholesterol levels is **familial dysbetalipoproteinemia** (or **familial combined hyperlipoproteinemia**) in which both cholesterol and triglyceride levels are elevated.

Role of cholesterol in heart disease

The medical term for an excessive amount of cholesterol in the blood (over 240) is *hypercholesterolemia*. It is one of the greatest threats to someone's health. Not only is it a major contributor to the development of hardened **arteries** (**atherosclerosis**), but it can also lead to a certain type of **chest pain** called **angina**, or even a **heart attack**. Research studies have concluded that for every 1 percent reduction in blood cholesterol level, the risk of **coronary heart disease** decreases by as much as 3 percent.

Although the National Center for Health Statistics reported that Americans' average total cholesterol levels dropped considerably between 1978 and 1990, the **American Heart Association** reported that 104.7 million American adults still have borderline-high cholesterol levels (200 to 239 milligrams per deciliter). Of these, about 37 million have high cholesterol levels (240 milligrams per deciliter). Taken together, these statistics mean that the average American's cholesterol level puts him or her at greater risk of heart disease or **stroke**.

Understanding cholesterol numbers

The guidelines for healthy cholesterol levels are set by the **National Heart, Lung and Blood Institute** (NHLBI). These guidelines apply to patients who are at low to moderate risk of having a heart attack in 10 years. Patients at moderately high to high risk are advised to follow more stringent guidelines.

The cholesterol levels for patients at low to moderate risk of a heart attack are as follows (in milligrams per deciliter [mg/dL]):

Total Cholesterol (Low-moderate risk)

Total Cholesterol Level	Category
Less than 200 mg/dL	Desirable
200 to 239 mg/dL	Borderline high
240 mg/dL and higher	High

LDL Cholesterol (Low-moderate risk)

LDL Cholesterol Level	Category
Less than 100 mg/dL	Optimal
100 to 129 mg/dL	Near optimal/above optimal
130 to 159 mg/dL	Borderline high
160 to 189 mg/dL	High
190 mg/dL and higher	Very high

HDL Cholesterol (Low-moderate risk)

HDL Cholesterol Level	Category
Less than 40* mg/dL	Low (increased risk)
60 mg/dL and higher	High (heart-protective)

* The **American College of Cardiology** recommends that women maintain HDL cholesterol levels of at least 45. For more information, see **Cholesterol and Women**.

Triglycerides (Moderate risk)

Triglyceride Level	Category
Less than 150 mg/dL	Normal
150 to 199 mg/dL	Borderline high
200 to 499 mg/dL	High
500 mg/dL and higher	Very high

Labs outside of the United States may use different units of measure for cholesterol levels. To convert a cholesterol level from milligrams per deciliter (mg/dL) to international units (IU), multiply the mg/dL cholesterol level by 0.0259 millimoles per liter (mmol/L). For example, a cholesterol level of 200 mg/dL is equal to a cholesterol level of 5.18 IU.

Hypercholesterolemia, or high cholesterol, is diagnosed by measuring total cholesterol levels, as well as by separate HDL ("good") and LDL ("bad") levels. The total cholesterol equals HDLs + LDLs + 1/5 triglycerides.

Directly measuring LDL cholesterol is both difficult and expensive. Fortunately, LDL can be reliably calculated by directly subtracting HDL and triglycerides (which are easier to measure) from the total cholesterol, as long as triglycerides are under 400. However, this formula becomes unreliable when triglyceride levels are over 400, in which case LDL must be directly measured.

Another calculation gives the **cholesterol ratio**, which is the total cholesterol divided by the HDL level. According to the **American Heart Association**, the level of total cholesterol should not be more than five times the level of good cholesterol. This may be expressed as the ratio 5:1.

A ratio of 3.5:1 is considered optimal. The goal is to keep the ratio below 5:1. Anything over 5:1 indicates a possibly unhealthy balance of LDL cholesterol in the blood. Regardless of total cholesterol, experts generally recommend that the level of HDL cholesterol should be at least 40 mg/dL in men and at least 45 mg/dL in women.

Low total cholesterol (below 160) is not directly harmful to the human body but could indicate the presence of other medical conditions that may require attention. These medical conditions include the following:

- **Hyperthyroidism**. An overactive **thyroid gland** that leads to an excess of thyroid hormone in the body.

- Malnutrition. Inadequate nutrition that may be caused by an unbalanced diet or a condition in which the body has difficulty digesting or absorbing nutrients from food (*malabsorption*).

- *Pernicious anemia*. A type of **anemia** (red blood cell deficiency) caused by the lack of a substance in the body needed to absorb vitamin B-12.

- *Sepsis*. A serious bacterial infection that has spread to the blood.

LDL and higher risk patients

Treatment for high cholesterol generally centers on reducing the most dangerous type of **lipid – low-density lipoproteins** (LDL). Because of this, guidelines for determining the appropriate LDL level vary depending on the patient's overall health. As noted in the previous section, for otherwise healthy patients, LDL levels are as follows:

LDL Cholesterol (Low-moderate risk)

LDL Cholesterol Level	Category
Less than 100 mg/dL	Optimal
100 to 129 mg/dL	Near optimal/above optimal
130 to 159 mg/dL	Borderline high
160 to 189 mg/dL	High
190 mg/dL and higher	Very high

Such guidelines are not sufficient for patients already at an increased risk of having a heart attack. For higher-risk patients, goals for LDL levels are set based on each patient's risk category. These "therapeutic goals" are as follows (in milligrams per deciliter [mg/dL]):

LDL Cholesterol (Higher-risk patients)

Risk Category	Primary Therapeutic LDL Goals	Secondary Therapeutic LDL Goals
Very High	Less than 100 mg/dL	Less than 70 mg/dL
High	Less than 100 mg/dL	n/a
Moderately High	Less than 130 mg/dL	Less than 100 mg/dL
Low/Moderate Risk	Less than 160 mg/dL	Less than 130 mg/dL

A "therapeutic goal" is the target that physicians hope to reach through therapies to lower their patients' LDL. Such therapy usually includes lifestyle changes (e.g., **diet and exercise**) and the use of **cholesterol reducing medications**. The two stages of therapeutic goals (primary and secondary) give physicians the option of a lower goal for some patients.

Risk categories are determined by the **National Heart, Lung and Blood Institute** (NHLBI) based on a person's likelihood of having a **heart attack** in the next 10 years. These **risk factors** include:

- Age (45 years or older for men; 55 years or older for women, or premature **menopause**)
- **High blood pressure**
- **Diabetes**
- **Smoking**
- A diet high in **saturated fats**
- **Obesity**
- Lack of exercise
- A **family history** of **cardiovascular disease**

LDL Cholesterol (Higher-risk patients)

Risk Category	Patients are in this category if they have...
Very High	Are at high risk (see below) AND Multiple risk factors, or severe and poorly controlled risk factors
High	**Coronary artery disease**, **peripheral arterial disease**, **cerebrovascular disease** or other form of **atherosclerosis** OR Diabetes OR Two or more known risk factors (see above) that give them a greater than 20 percent risk of heart attack within 10 years
Moderately High	Have two or more risk factors for coronary heart disease, together with a 10 to 20 percent risk of heart attack within 10 years
Low/Moderate Risk	None of the above factors

Frequency of cholesterol screening

Regular **cholesterol screenings** are important. The **National Cholesterol Education Program** recommends that both males and females 20 years of age and older have a "lipid profile" (or cholesterol test) every five years. Regular cholesterol screenings are particularly important for people who have risk factors such as **diabetes**, **obesity** or a **family history** of **cardiovascular disease**. Such higher risk individuals, and people over age 65, may be screened more frequently.

Even children can benefit from having their cholesterol checked, because it is one way to identify factors that may adversely affect their heart health as they grow. It has been reported that approximately 50 million children in the United States have high cholesterol levels, which is defined as total cholesterol of 200 milligrams per deciliter (mg/dL).

Category	Total Cholesterol (mg/dL)	LDL Cholesterol (mg/dL)
Acceptable	Less than 170 mg/dL	Less than 110 mg/dL
Borderline	170-199 mg/dL	110-129 mg/dL
High	200 mg/dL or greater	130 mg/dL or greater

However, the U.S. Preventative Services Task Force does not encourage the routine screening of all young children because coronary artery disease tends to begin later in life. Furthermore, starting young children on medication to treat high cholesterol may be more of a risk than the early **plaque** build-up it is meant to prevent. Recent studies have shown that a prescribed, moderate regimen of vitamins C and E can help slow the progression of **atherosclerosis** in children with abnormally high cholesterol levels.

Cholesterol screening is fast and relatively painless. Blood is drawn from a **vein** or through a fingertip "prick test." Regular screenings are the first line of defense against developing high cholesterol levels. If **triglyceride** levels are going to be measured, test participants will be asked to stop eating or drinking for approximately nine hours prior to the screening.

This cholesterol screening is only an approximate indication of one's cholesterol level. Even under normal conditions, the test results may be higher or lower than a person's actual cholesterol levels by about 14 percent. Also, test results can vary quite a bit even when repeated over a short period of time. Therefore, many physicians will provide results as a cholesterol range (e.g., 150 to 160) rather than an exact number.

Gender differences in cholesterol

Women benefit from cholesterol-lowering activities as much as men do. Beyond age 45, a greater percentage of women have high cholesterol levels than men, and **heart disease** has emerged as the leading cause of death among women. It has also been shown that **HDL** levels tend to drop in women who have just given birth, and that this reduction can continue for as long as 10 years. However, women are far less likely to seek or receive treatment for **high cholesterol**.

Studies have suggested that high **LDL** levels are not as significant a **risk factor** for women as for men. Researchers suggest that apolipoprotein B (apoB), a protein found in low-density lipoproteins, is the best cholesterol-related predictor of **coronary artery disease** for women (recent studies find that apoB is an equally useful "marker" for men as well). It has also been shown that HDL levels tend to drop in women who have just given birth, and that this reduction can continue.

Other measures are also being investigated. **C-reactive protein**, a blood-marker that indicates inflammation, may be a better predictor of heart attack than LDL levels. Measuring both C-reactive protein and LDL seems to be even more reliable, but these findings are still under investigation and no clinical guidelines have been developed.

As gender-specific research continues, women will probably see an increased availability of information and protocols for monitoring their cholesterol levels.