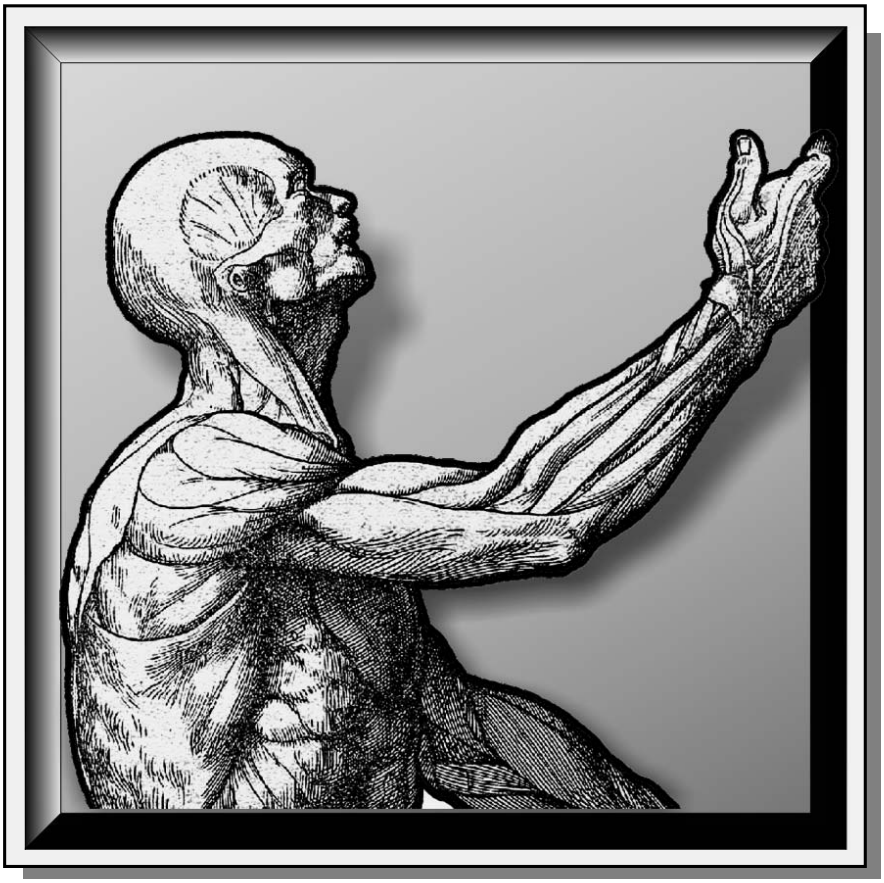
# *Precepts of Anatomy & Physiology*

**This chapter requires a companion activity book in which students respond to questions on text content. Answers are found in the *Teacher's Resource Kit*.**



# *Chapter 2*

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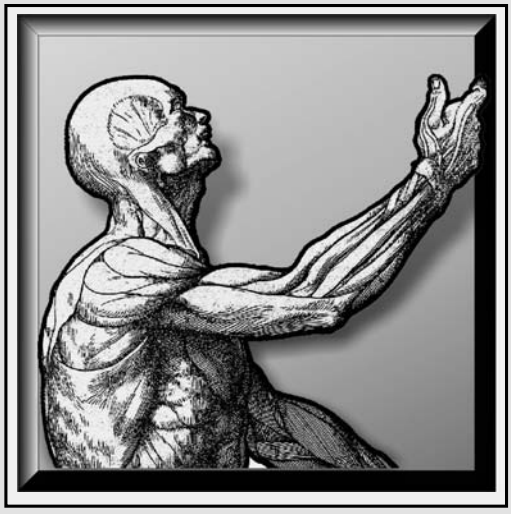

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Anatomy and physiology is the study of the structure, function and relationships of your marvelous bodily components. Your task is to use these resources wisely.

—Nancy S. Johnson





The Human Body

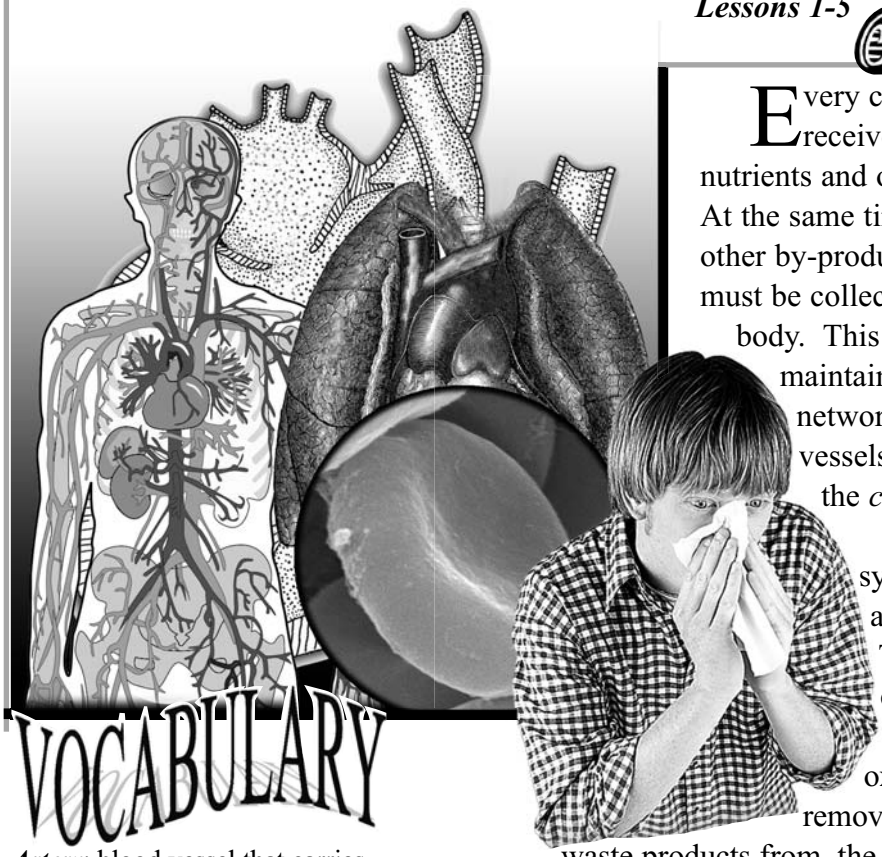
**Lesson 1**

# *Chapter 2*

## THE HUMAN BODY: THE CIRCULATORY SYSTEM—INTRODUCTION

## Section 1

***Lessons 1-5***



## VOCABULARY

***Artery***: blood vessel that carries blood from the heart to the body
***Aorta***: largest artery in the body; brings oxygen-rich blood from the left ventricle to the rest of the body
***Pulmonary artery***: artery that leaves the right ventricle, then branches into two arteries to take oxygen-poor blood to the lungs for oxygenation
***Capillary***: small blood vessel in which the exchange of nutrients and wastes take place
***Vein***: blood vessel that returns blood to the heart
***Venule***: vessel into which capillaries converge and empty into veins

Every cell in your body must receive a continuous supply of nutrients and oxygen in order to stay alive. At the same time, carbon dioxide and other by-products of cellular metabolism must be collected for removal from the body. This process is constantly maintained by the body's vast network of blood vessels. These vessels are collectively known as the *circulatory system*.

The primary circulatory system consists of the heart and the blood vessels. Together, they maintain a continuous flow of blood through the body, delivering oxygen and nutrients to, and removing carbon dioxide and waste products from, the peripheral tissues.

The heart is an incredible marvel of precision engineering, and is the main component of the circulatory system. The design of the human heart features four chambers with their accompanying four valves through which blood must pass on each trip around the body. At the rate of about 70 beats per minute, the heart pumps oxygen-rich blood from the lungs to all parts of the body through a network of blood vessels—an engineering marvel observable to any serious student.

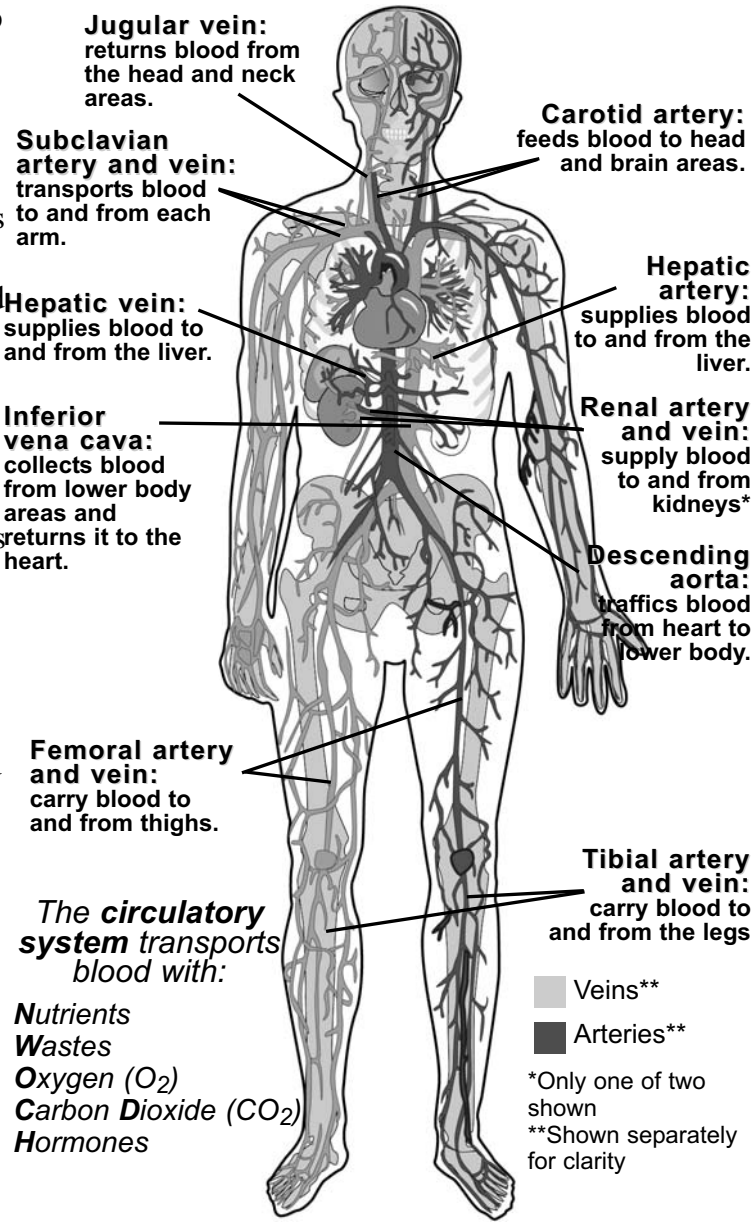
A small organism with a few cells does not really need a circulatory system. Most cells in such organisms are in direct contact with the environment so that oxygen, nutrients, and wastes can diffuse easily across cell membranes from the outside. Larger organisms, however, require more sophistication in delivering oxygen and removing wastes. Some creatures such as crayfish and shrimp have *open* circulatory systems. Each of these organisms have hearts in

the upper regions of their bodies which pump blood into short vessels that empty into various cavities of the body. This allows blood to flow directly over all of the cells in that cavity.

Still larger organisms such as mammals need a more sophisticated circulatory system. The needs of a large mammal can be compared with a large city. A city transportation system is necessary for moving people, goods and waste materials efficiently from one place to another. The transportation system of a city is its streets, highways and railways. The transportation system of a living organism is its circulatory system.

Humans and other vertebrates have *closed* circulatory systems, which means that blood is pumped through a system of vessels. The human circulatory system consists of the heart and 60,000 miles of blood vessels filled with blood.

## Human Circulatory System




## VOCABULARY

***Upper (superior) vena cava***: large vein that brings oxygen-poor blood from the upper part of the body to the right atrium

***Lower (inferior vena cava)***: large vein that brings oxygen-poor blood from the lower part of the body to the right atrium

***Pulmonary veins***: two veins which bring oxygen-rich blood from each of the lungs to the left atrium

***Blood pressure***: measure of the force exerted by blood against the walls of arteries

***Smooth muscle***: spindle-shaped, unstriated muscle tissue found in internal organs and blood vessels; not under conscious control of the nervous system

## Blood Vessels

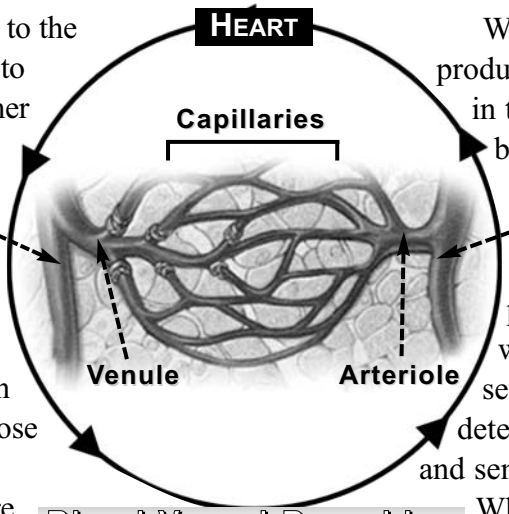
Blood vessels are multi-layered, muscular tubes that carry blood to and from all parts of the body. The human circulatory system is made up of three main types of blood vessels: *arteries*, *capillaries* and *veins*.

***Arteries*** are the superhighways of the circulatory system. Arteries are blood vessels that carry blood from the heart throughout the body. Arteries have thick elastic walls that can withstand the powerful surges of blood produced by the heart. The

lining of an artery is surrounded by layers of elastic tissue and smooth muscle cells that allow the artery to expand under pressure. As they lead farther from the heart, arteries branch into smaller vessels called *arterioles*. The ***aorta*** is the largest artery in the body. It brings oxygen-rich blood from the heart to the rest of the body. The ***pulmonary arteries*** transport oxygen-poor blood to the lungs.

***Capillaries*** are the smallest of the three blood vessel types and can be compared to the small alleys and side streets in the city. The exchange of nutrients and wastes takes place in the capillaries. Their walls are only one cell thick. Some capillaries are so narrow that blood cells must travel through in single file! Scientists estimate that more than ten billion capillaries lace the human body in order to carry blood within the reach of every cell. As blood flows through capillaries in the lungs, carbon dioxide waste is released and oxygen is absorbed. Blood flows through the tissue capillaries to pick up carbon dioxide and other wastes and delivers oxygen to the cells. Capillaries converge to form ***venules*** and then further converge to form ***veins***.

Veins are vessels that carry blood from the capillaries of the organs and tissues toward the heart. Veins have small valves that open to let blood through and close to prevent it from flowing backwards. Many veins are located near skeletal muscles and the contractions of those muscles help to push blood along to the heart. The structure of veins is similar to that of arteries, but vein walls are neither as thick, nor as elastic, because less force from the flow of blood is exerted on the walls of veins.



Blood Vessel Branching

Blood doesn't flow at the same speed in all parts of the body. It spurts from the heart very quickly, but by the time it reaches the capillaries it has slowed down to a gentle stream. One at a time, red blood cells squeeze through the narrow channels of the capillaries. In most parts of the body, each cell is only a millionth of an inch from a capillary. Like water in streams that join rivers that return to the sea, blood flows slowly at first after it leaves the capillaries. As veins link together, blood speeds up and comes back to the heart in a steady current. Four major veins feed blood through four valves into the four chambers of the heart: the ***upper (superior) vena cava*** which carries blood from the brain and the chest; the ***lower (inferior) vena cava*** that carries blood from the stomach and lower body, plus two ***pulmonary veins*** that bring oxygen-rich blood from each of the lungs to the heart.

## Blood Pressure

When the heart contracts, it produces a wave of fluid pressure in the arteries. The force of blood on the walls of the arteries is known as ***blood pressure.*** The body regulates blood pressure in two different ways. Sensory neurons at several places in the body detect the level of blood pressure and send impulses to the brainstem. When blood pressure is too high, the autonomic nervous system releases neurotransmitters that cause the ***smooth muscles*** around blood vessels to relax, thus lowering blood pressure. When blood pressure is too low, neurotransmitters are released to elevate blood pressure by causing these smooth muscles to contract.

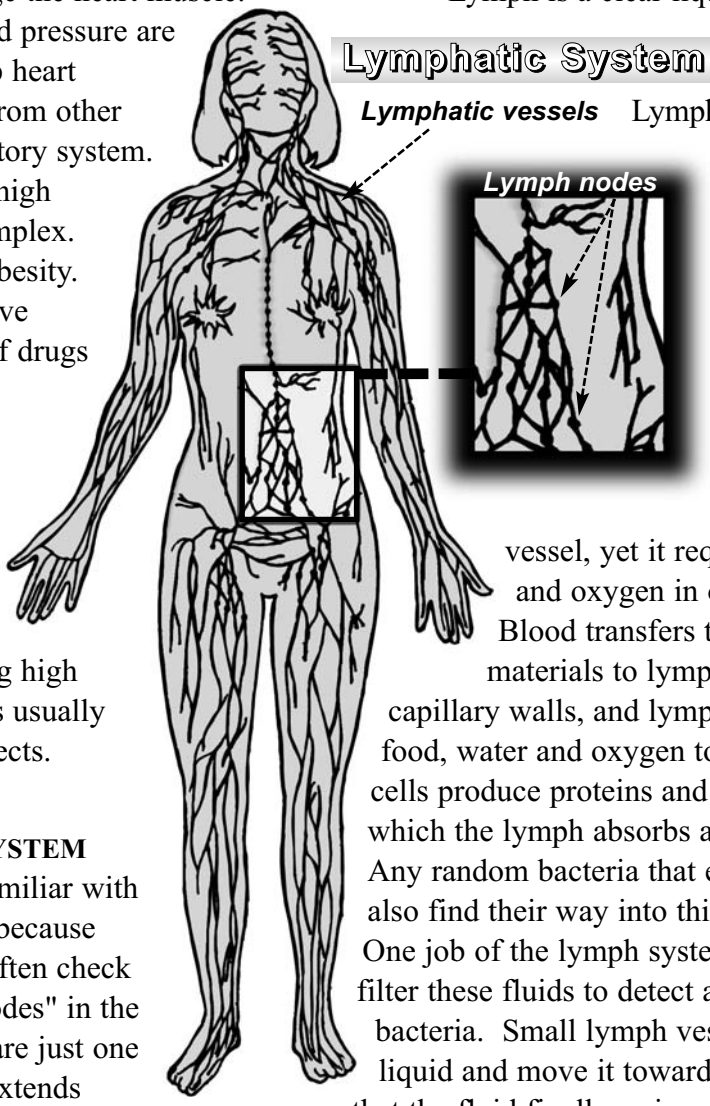
The kidneys also help to regulate blood pressure. Hormones produced by the heart and other organs cause the kidneys to remove more water from the blood when blood pressure is high. This reduces blood volume and lowers blood pressure.

Medical problems may result if blood pressure is too high or too low. High blood pressure forces the heart to work harder, which may weaken or damage the heart muscle. People with high blood pressure are more likely to develop heart disease and to suffer from other diseases of the circulatory system.

The causes of high blood pressure are complex. One known cause is obesity. Although scientists have developed a number of drugs that can lower blood pressure, high blood pressure is easier to prevent than to cure. Exercise, weight control and a sensible diet seem to be the keys to avoiding high blood pressure. Drugs usually have negative side effects.

## LYMPHATIC SYSTEM

You may be familiar with the lymphatic system because doctors and mothers often check for "swollen lymph nodes" in the neck. Lymph nodes are just one part of a system that extends throughout your body in much the same way as your blood vessels. The main difference between the blood flowing in the circulatory system and the lymph flowing in the lymph system is that blood is pressurized by the heart, while the lymph system is passive. No "lymph pump" exists like the "blood pump" (the heart). Instead, fluids ooze into the lymph system and get pushed by normal body and muscle motion to the lymph nodes. This is very much like the water and sewer systems in most communities. Water is actively pressurized, while sewage is usually passive and flows by gravity.




Lymph is a clear liquid that bathes the cells with water and nutrients. Lymph is blood plasma—the liquid that comprises blood—minus the red and white cells. Each cell does not have its own private feeder blood vessel, yet it requires food, water, and oxygen in order to survive. Blood transfers these three materials to lymph through the capillary walls, and lymph carries the food, water and oxygen to the cells. The cells produce proteins and waste products which the lymph absorbs and carries away. Any random bacteria that enter the body also find their way into this inter-cell fluid. One job of the lymph system is to drain and filter these fluids to detect and remove the bacteria. Small lymph vessels collect the liquid and move it toward larger vessels so that the fluid finally arrives at the lymph nodes for processing.

Lymph nodes contain filtering tissue and a large number of lymph cells. When fighting certain bacterial infections, the lymph nodes swell with bacteria, and the

cells fighting the bacteria, to the point where you can actually feel them. Swollen lymph nodes are therefore a good indication that you have an infection of some sort.

Once lymph has been filtered through the lymph nodes it re-enters the bloodstream.

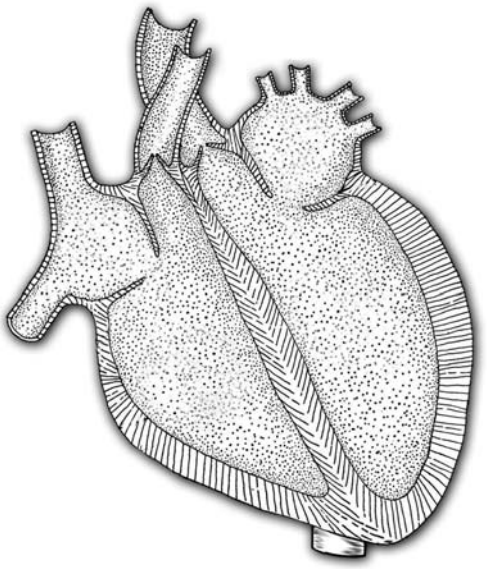
**In the next lesson, we will continue our study of the circulatory system by examining the heart.**

# LIFE PRINCIPLE



**"At the heart of every social issue is the nature of the human heart."**

—Ronald E. Johnson, C. Ph.D.
Educator, author





The Human Body

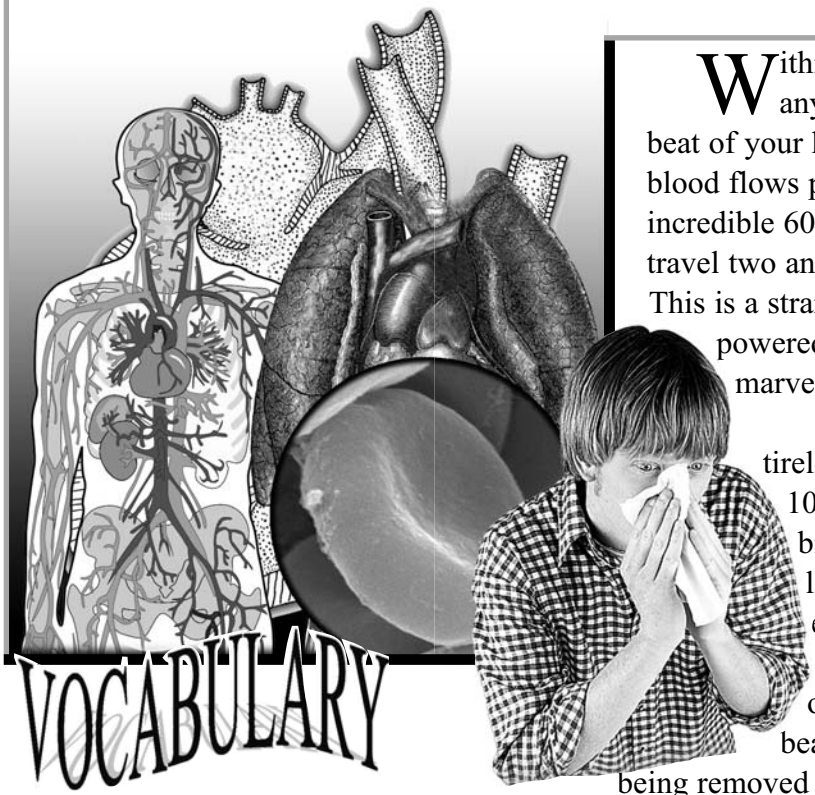
**Lesson 2**

# Chapter 2

## THE HUMAN BODY: THE CIRCULATORY SYSTEM—THE HEART

## Section 1

***Lessons 1-5***



Within each of us flows a river unlike any river on the earth. With every beat of your heart, this life-sustaining river of blood flows past every cell of your body on an incredible 60,000-mile voyage, enough to travel two and a half times around the world! This is a strange and wonderful voyage, all powered by one mysterious and marvelous organ—the heart.

The average heart beats tirelessly at an average of about 100,000 times a day—some 2 to 3 billion times in the average lifetime. The heart beats without external nerve regulation, except to control the speed and strength of its beat; it can even continue beating for several minutes after being removed from the body. The heart moves about 2,000 gallons of blood each day; which equals approximately 680,000 gallons each year! The heart is as powerful as a mechanical pump that can propel a jet of water six feet high into the air!

In order to accomplish its purpose, the cardiac muscle is supplied with more capillaries than any other tissue. It uses about 80 percent of the oxygen supplied by the blood, compared with about 25 percent used by most other tissues. The heart works hard even when we relax or sleep, and harder yet when we work or exercise, never stopping for rest or repair. Scientists marvel at the human heart as a most incredible organ.

Not every creature, however, has a heart. Some simple organisms exist in oceans and ponds that take in food and oxygen from surrounding waters but do not have hearts. In humans and other more complex animals, the heart is critical for delivering nutrients and eliminating wastes.

### VOCABULARY

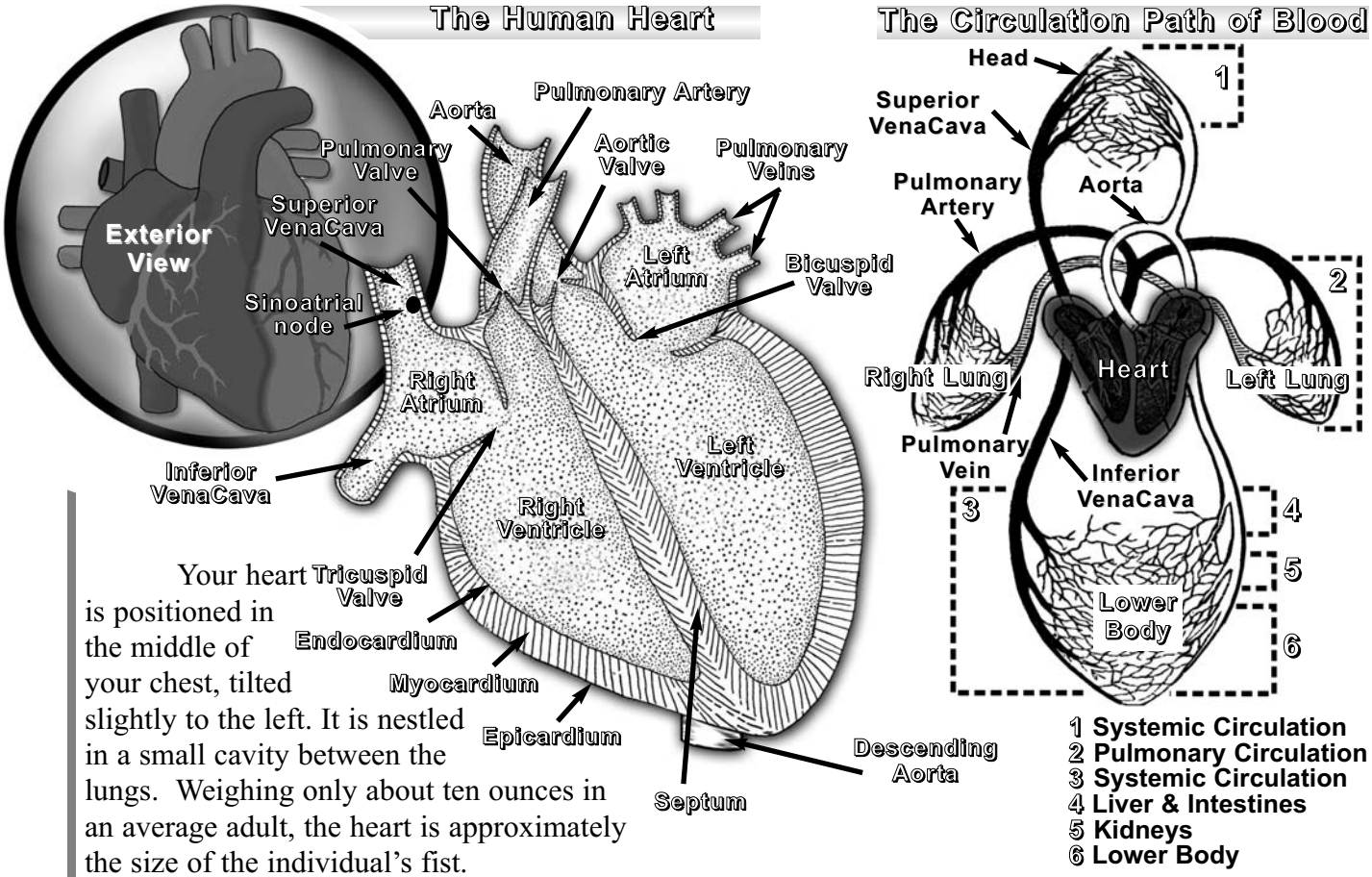
***Atrium (pl. atria)***: upper chamber of the heart that receives the blood

***Ventricle***: lower chamber of the heart that pumps blood out of the heart

***Septum***: dividing wall membrane

***Pulmonary circulation***: pathway of blood vessels on the right side of the heart that carries blood between the heart and the lungs

***Systemic circulation***: pathway of blood vessels on the left side of the heart that supplies the body with oxygen-rich blood and returns oxygen-poor blood to the heart




Your heart is positioned in the middle of your chest, tilted slightly to the left. It is nestled in a small cavity between the lungs. Weighing only about ten ounces in an average adult, the heart is approximately the size of the individual's fist.

The human heart is like two separate pumps sitting side by side. Each side has two chambers: an ***atrium*** and a ***ventricle***. The atria and ventricles are divided into left and right sections by a thick wall called the ***septum***. It is through the rhythmic action of the myocardium muscles in the walls of these chambers that blood is pushed throughout the entire circulatory system. The atria serve as the *blood-receiving* chambers of the heart, and the ventricles serve as the *blood-pumping* chambers that force blood through the blood vessels.

Each side of the heart pumps blood to a different part of the circulatory system. The right side of the heart pumps blood from the heart to the lungs. This pathway is called ***pulmonary circulation***. *Oxygen-poor* blood is pumped by the right side of the heart through the lungs, where it gives off carbon dioxide and picks up oxygen. This *oxygen-rich* blood is then returned to the left side of the heart by the pulmonary veins.

The left side of the heart pumps blood to the rest of the body. This pathway is called ***systemic circulation***. Oxygen-rich blood leaves the heart to supply the body with oxygenated blood. By the time blood returns from this systemic circulation, cells throughout the body have absorbed much of the blood's oxygen and exchanged carbon dioxide for it. The blood is now oxygen-poor

## VOCABULARY

***Sinoatrial node***: also known as the pacemaker; area of the heart that regulates the heartbeat

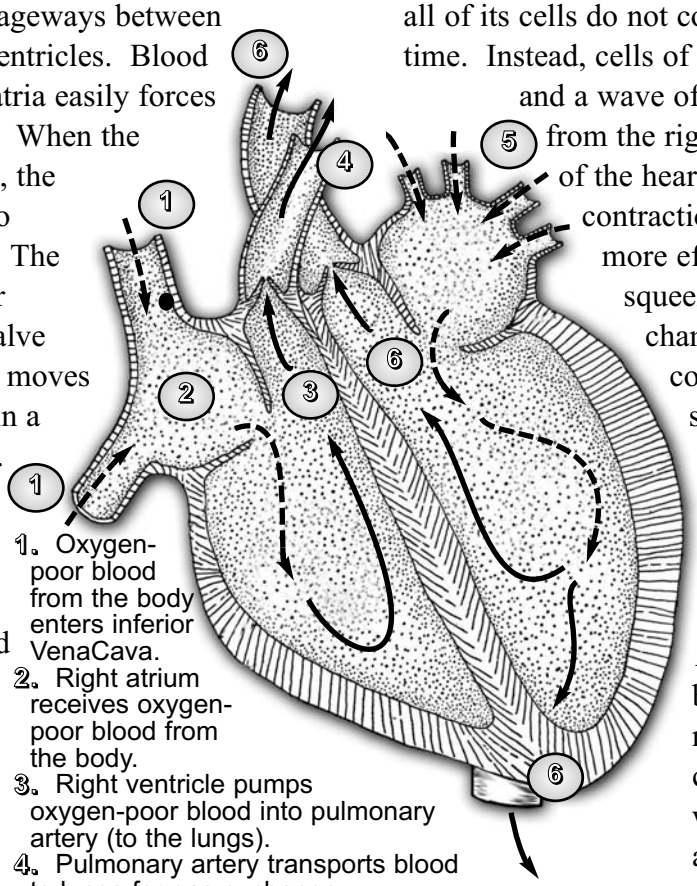
***Medulla oblongata***: part of the brainstem that regulates the flow of information between the brain and the rest of the body; controls involuntary functions

and ready for another trip to the lungs to become oxygen-rich again. Study the illustrations in this lesson.

## Blood Flow

Blood enters the heart's atria through the superior vena cava, the inferior vena cava and the pulmonary veins. As the heart contracts, blood is forced first into the ventricles, then out from the ventricles into circulation. Special flaps called *valves* open and close the passageways between the atria and the ventricles. Blood moving from the atria easily forces these valves open. When the ventricles contract, the valves slam shut to prevent backflow. The heart contains four valves and each valve ensures that blood moves through the heart in a one-way direction.

The oxygen-rich blood leaves the left ventricle via the aorta and is carried to the rest of the body. Oxygen-poor blood leaves the right ventricle via the pulmonary artery and is carried to the lungs for gas exchange. This "traffic control" system arguably reflects a design superior to man's most efficient mechanical engineering achievements.




William Harvey, the 15th century physician, noted for discovering the way blood circulates within the human body, wrote:

*The heart of creatures is the foundation of life, the Prince of all, the Sun of their microcosm, ...from whence all vigor and strength flow.*

## Heartbeat

Although the heart is a single muscle, all of its cells do not contract at the same time. Instead, cells of the atria contract first, and a wave of contraction spreads from the right atrium over the rest of the heart. This pattern of contraction makes the heart a more efficient pump, squeezing blood from one chamber to the next. Each contraction begins in a small group of cells, called the ***sinoatrial node***, or the *pacemaker*, located in the superior vena cava near the right atrium. Although the heart beats without outside nerve stimulation, changes in the rate at which the heart beats are under the control of the central nervous system. The sinoatrial node is controlled by the *heart rate center* located in the ***medulla oblongata.*** The heart rate center is, in turn, influenced by many factors, including pressure receptors in arteries and

veins, emotions such as fear, hormones such as adrenaline, and environmental factors such as temperature.

Although scientists have a thorough understanding of the heart and its functions, they do not have any idea what causes the pacemaker to work. The mysterious pacemaker stimulates the heart an average of 60-100 times a second. Scientists have found nothing tangible that stimulates the pacemaker. It simply works according to the way it is programmed to operate. To add to the mystery, children's heart rates range from 90 to 120 beats per minute. The pulse rate in adults, however, is between 60 and 100 beats per minute. Scientists are at a loss to explain how the pacemaker "knows" to slow down as the human body develops from childhood to adulthood.

When a person succumbs to a long illness, the heart is the last organ to fail, and, of that, the sinoatrial pacemaker is the last group of heart cells to expire.

**In the next lesson, we will conclude our study of the circulatory system by studying the blood.**

## LIFE PRINCIPLE



**"Keep your heart with all diligence, for out of it are the issues of life."**

—Ancient Hebrew proverb



The Human Body

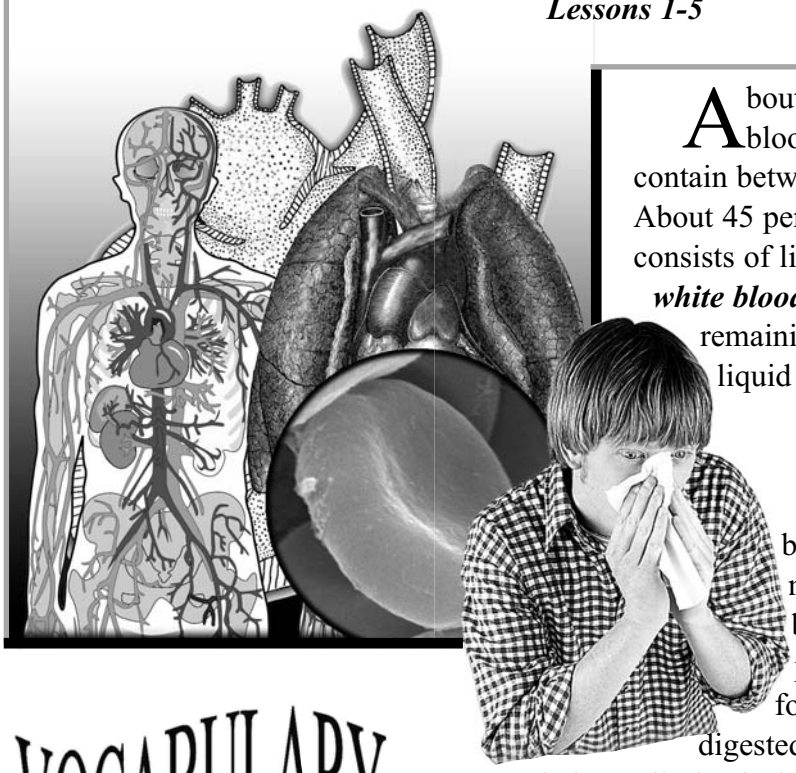
Lesson 3

# Chapter 2

## THE HUMAN BODY: THE CIRCULATORY SYSTEM—THE BLOOD

## Section 1

*Lessons 1-5*

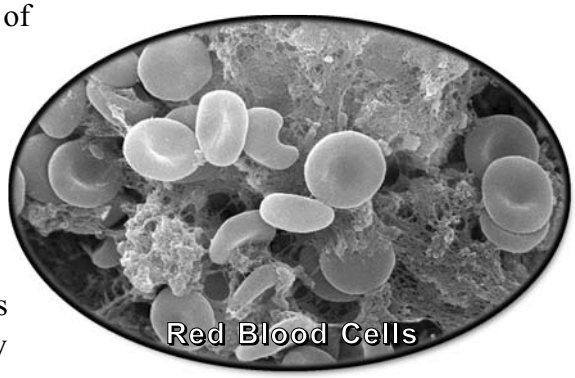


About 8 percent of human body mass is blood. For most of us, that means we contain between four and six quarts of blood. About 45 percent of the volume of blood consists of living cells called ***red blood cells***, ***white blood cells*** and ***platelets***. The remaining 55 percent is a clear, pale-gold liquid called ***plasma***.

### Plasma

Plasma is 90 percent water, but also contains many proteins, minerals and sugars used by the body to build and repair cells. As plasma travels throughout the body, food nutrients that have been digested in the stomach and small intestine are carried to cells for fuel. Because plasma is a liquid, it can pass through the walls of small blood vessels right into the cells. Blood plasma also helps to regulate the body's temperature, moving heat from deep within the body to the skin, head, arms and legs.

Three groups of plasma proteins circulate. The first is called *serum albumin* which is proteins that help to regulate osmotic pressure. Another type of protein, called *globulins*, is produced by the immune system and helps to protect against infection. The last group of plasma proteins is *fibrinogen*, which regulates blood clotting.



Red Blood Cells

### Red Blood Cells

Red blood cells are the most common cells in the human body. Every

## VOCABULARY

***Red blood cells***: blood cells that contain hemoglobin; constitute nearly half the total volume of blood; also called *erythrocytes*

***White blood cells***: blood cells that fight infection, parasites and bacterial disease; also called *leukocytes*

***Platelets***: cell fragments in the blood that aid in blood clotting

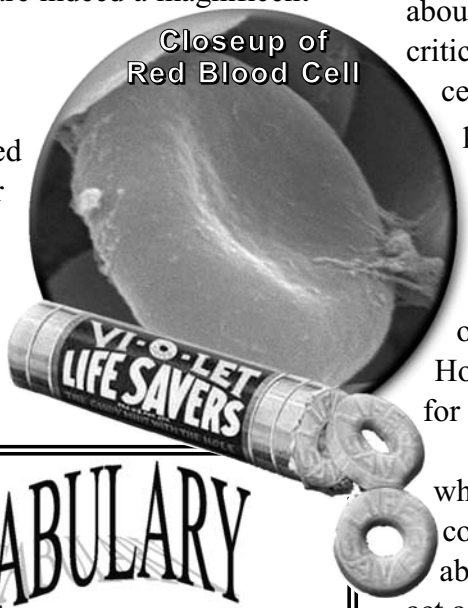
***Plasma***: fluid part of the blood; constitutes about 55 percent of total blood volume

***Hemoglobin***: iron-containing protein found in red blood cells; helps to transport oxygen

human has about 25 trillion red blood cells, hundreds of times more blood cells than stars in the Milky Way galaxy! Their scientific name—*erythrocytes*—means "red cells" and comes from ***hemoglobin***, the bright-red substance within the blood cells. Hemoglobin is an iron-containing protein which enables the red blood cells to carry oxygen. As red blood cells pass through the lungs, the hemoglobin within them quickly absorbs oxygen. When the same cells pass through capillaries in oxygen-poor regions of the body, oxygen is released into the surrounding tissues.

Red blood cells are produced in the bone marrow. As red blood cells develop, they lose their nuclei and their ability to divide. A typical red blood cell has a life span of about four months, which means our bodies must be busy replacing red blood cells as they die. Every second of every 24-hour day, your body makes about three million red blood cells. You are indeed a magnificent "machine".

A most fascinating characteristic of red blood cells is their shape. The shape of the normal erythrocyte is a *bioconcave* disc. This shape allows maximum surface contact of hemoglobin with the cell, thus facilitating an efficient exchange of blood gases. In fact, researchers at International Business Machines (IBM) did a study on the ideal shape of a solid object that would maximize oxygen diffusion. After conducting numerous simulations on an IBM mainframe computer, this bioconcave or "lifesaver" shape was determined to be the optimal shape. This shape also gives the red blood cell flexibility, elasticity and allows the cell to be folded when it has to move through very narrow blood capillaries. The smooth, round edges reduce the amount of friction the cell may encounter in the microscopic capillaries. Scientists marvel at the sophisticated design in the red blood cell.




## VOCABULARY

***Arteriosclerosis***: condition in which mineral and fatty deposits build up on the inner surfaces of arteries; also known as "hardening of the arteries"

## White Blood Cells

White blood cells do not contain hemoglobin. Although white blood cells are normally outnumbered by red blood cells by about 500 to 1, white blood cells have the critical job of fighting disease. White blood cells guard against infection, fight parasites and attack bacteria. Like red blood cells, white blood cells are formed in the bone marrow. White blood cells usually have a much shorter life span than red blood cells, living only a few days to a few weeks. However, some white blood cells can live for months and even years.

More than 20 different types of white blood cells are known. The most common are the *neutrophils*. They are about twice the size of red blood cells and act against bacteria. Attracted by chemicals released by bacteria, neutrophils move to an infection and start to engulf the germs, destroying them. The pus that forms at the point of an infection is composed primarily

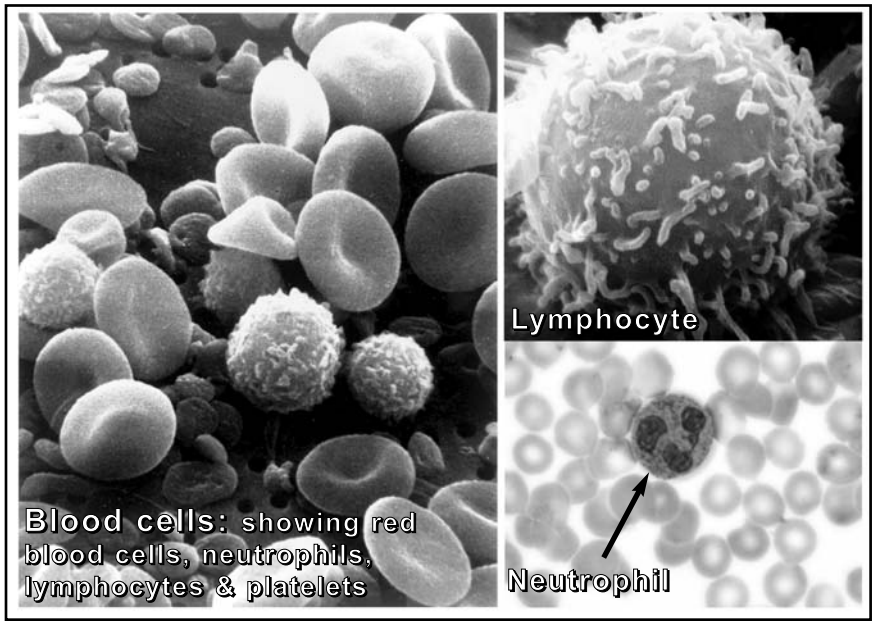
of white blood cells that died while defending the body. *Lymphocytes* are the second most common of white blood cells. Lymphocytes produce antibodies that fight against infection.

| Blood Cell Functions | |
|---|---|
| Red Blood Cells | Deliver oxygen, nutrients, hormones to body tissues<br>Remove wastes and carbon dioxide from body tissues |
| White Blood Cells | Fight disease, infection |
| Platelets | Clot to prevent blood loss |

Like an army with units in reserve, the body is able to increase the number of white blood cells dramatically when an "invader" appears. In fact, a sudden increase in the number of white blood cells is one way in which physicians can tell that the body is fighting a serious infection. We will take a closer look at white blood cells in a future lesson on the body's immune system.

## Platelets and Blood Clotting

When you cut or scrape yourself, you normally bleed for just a short while. Fortunately, your body responds by clotting the blood at the site of the wound. Platelets, along with a myriad of other chemicals, are responsible for blood clotting. When platelets encounter the broken edges of a blood vessel, their surfaces become sticky, and a cluster of platelets develops around the wound. These platelets then release a series of chemicals that help to start a very complicated reaction. About a dozen factors are involved in the clotting cascade that restores wounded tissue. This cascade of reactions results in the formation of *fibrin*, which forms a netlike surface that covers the wound and traps the red blood cells. If the wound is small, a network of platelets and fibrin seals the leak within a few minutes and bleeding stops. These finely tuned and interdependent biochemical interactions are examples of irreducible complexity, meaning that all aspects of the situation must be working simultaneously or it will not function at all.



Blood cells: showing red blood cells, neutrophils, lymphocytes & platelets

## Diseases of the Circulatory System

Unfortunately, diseases of the circulatory system are common. Many of them stem from a condition known as ***arteriosclerosis***, in which mineralized, fatty deposits build up on the inner surfaces of arteries. If these deposits become too large, they narrow the artery and obstruct the flow of blood. Arteriosclerosis is particularly dangerous in the coronary arteries, a set of arteries that

bring oxygen and nutrients to the heart muscle itself. If one of these becomes blocked, part of the heart muscle may begin to die from lack of oxygen. This condition is known as a *heart attack*. The symptoms of a heart attack include (but are not limited to):

*Nausea

*Shortness of breath

*Radiating pain down the left arm

*Jaw pain

*Severe, crushing chest pain.

When the blood vessels leading to part of the brain become blocked, a stroke results. According to the American Stroke Association, stroke symptoms include:

*Sudden numbness or weakness of the face, arm or leg, especially on one side of the body

*Sudden confusion, trouble speaking or understanding

*Sudden trouble seeing in one or both eyes

*Sudden trouble walking, dizziness, loss of balance or coordination

*Sudden, severe headache with no known cause.

People who show symptoms of a heart attack or stroke should be given immediate medical attention.

Brain cells served by a blocked blood vessel gradually die from lack of oxygen, and brain function in that region may be lost. Depending on the part of the brain that is affected, a stroke may cause paralysis, loss of the ability to speak or even death.

Arteriosclerosis often can be avoided by moderate exercise, a diet rich in fiber, and other healthful practices.

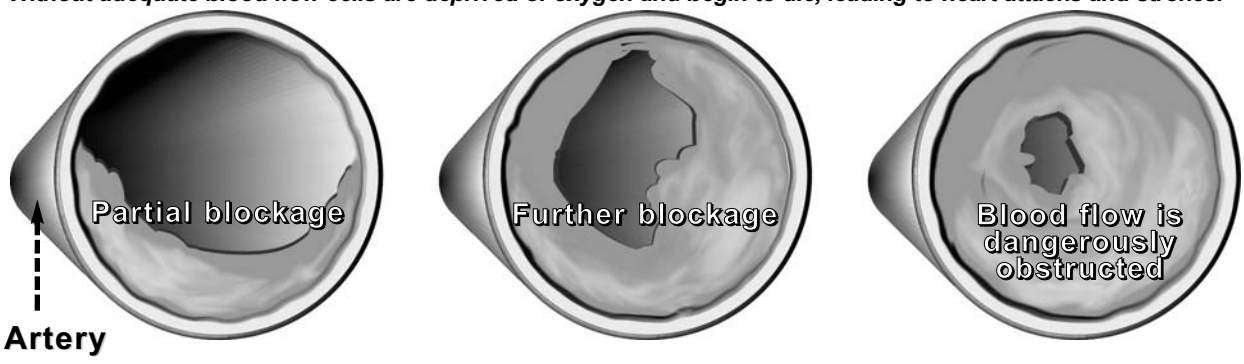
**In the next lesson, we will learn about the respiratory system.**

***Career Bound?***

A hematologist is a physician who specializes in treating diseases of the blood.

## Stages of Arteriosclerosis

***Arteries become hardened as fatty deposits build up within interior walls, causing obstructed blood flow. Without adequate blood flow cells are deprived of oxygen and begin to die, leading to heart attacks and strokes.***




# LIFE PRINCIPLE



**"...the life of the flesh is in the blood."**

—Moses, circa 1500 BC, Ancient Hebrew prophet and law-giver



Lesson 4

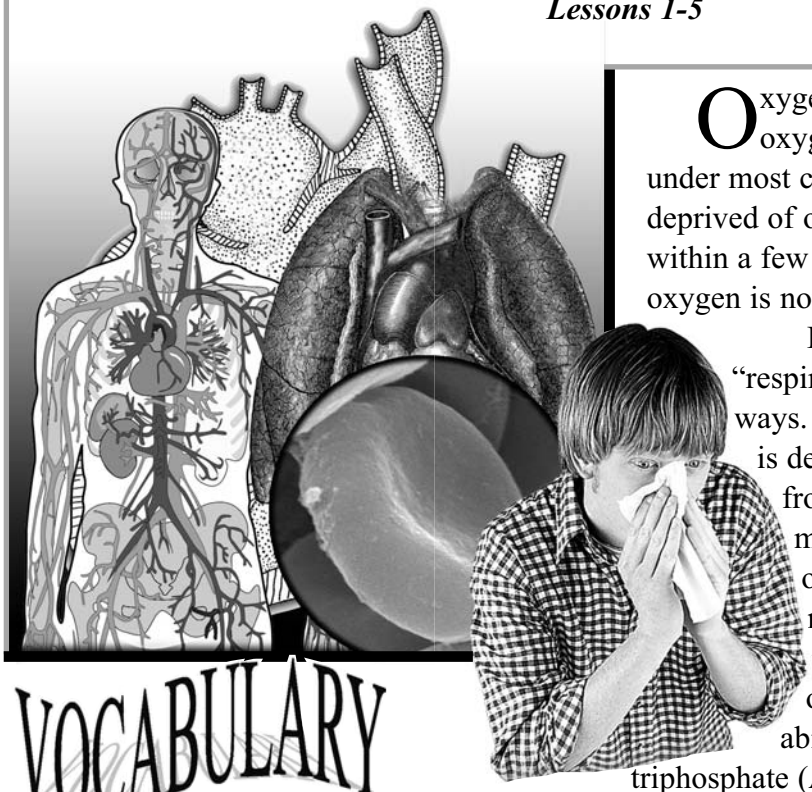
The Human Body

# Chapter 2

## THE HUMAN BODY: THE RESPIRATORY SYSTEM

## Section 1

*Lessons 1-5*



Oxygen is essential to life. Without oxygen, life is terminated. In fact, under most circumstances, if the brain is deprived of oxygen, brain damage occurs within a few minutes. A person will die if oxygen is not restored to the body quickly.

In biology and anatomy, the word "respiration" is used in slightly different ways. At the *cellular* level, respiration is defined as the release of energy from the breakdown of food molecules in the presence of oxygen. Every cell in the body needs oxygen to perform its metabolic processes. Without oxygen, cells lose much of their ability to produce adenosine triphosphate (ATP), which means that they cannot synthesize new molecules, pump ions, carry nerve impulses or even move.

Because millions of cells have an immediate, simultaneous need for oxygen, the human body incorporates a combination of the respiratory and circulatory systems to transport oxygen to all cells. The body must also dispose of carbon dioxide, produced when food molecules are broken down. Respiration occurs at the *organism* level by breathing. In this process, respiration is the exchange of oxygen and carbon dioxide between the organism and the environment.

### VOCABULARY

***Pharynx***: muscular structure in the back of the mouth; connects the mouth with esophagus and the rest of the digestive tract

***Trachea***: tube that carries air from the larynx to the lungs; also called the windpipe

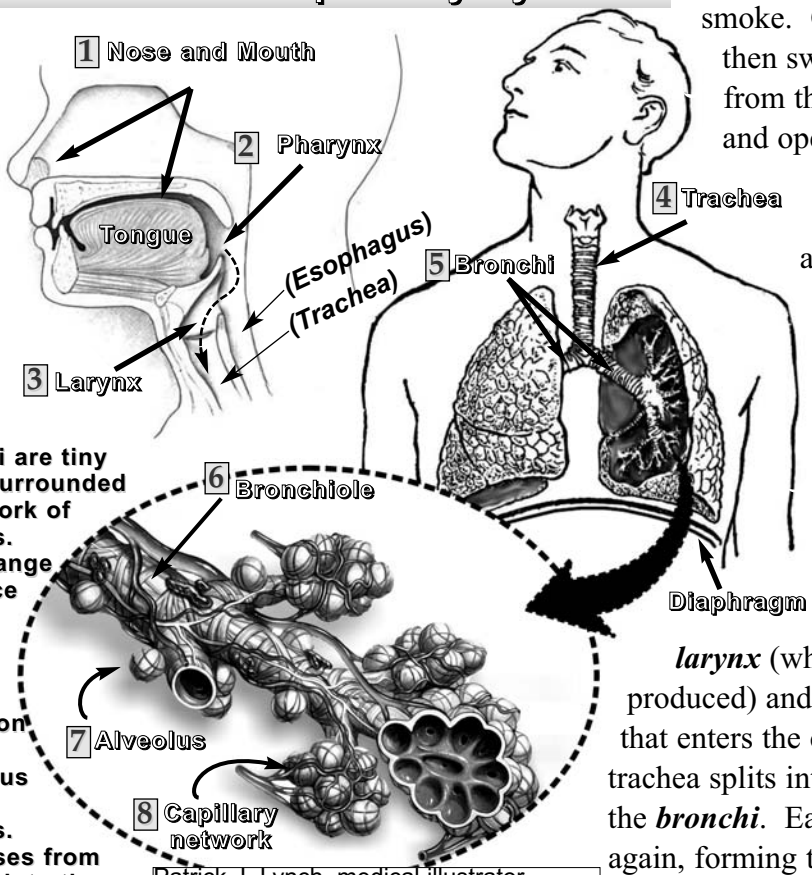
***Diaphragm***: dome-shaped muscle that pulls the bottom of the chest cavity downward, increasing its volume; main muscle used for breathing; separates the chest cavity from the abdominal cavity

***Larynx***: structure in which air enters the respiratory system and the vocal cords are located

### Human Respiratory Process

The primary function of the respiratory system is to supply the blood with oxygen and to rid the body of carbon dioxide. The respiratory system does this through breathing. With each breath, air enters the body through the air passageways and fills the lungs, where gas exchange takes place. This exchange of gases is the respiratory system's means of getting oxygen to the blood.

## The Human Respiratory System




Patrick J. Lynch, medical illustrator
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**Alveoli:**
**The aveoli are tiny air sacs surrounded by a network of capillaries. Gas exchange takes place in the alveoli. $O^2$ enters the blood by diffusion through the alveolus into the capillaries. $CO^2$ diffuses from the blood into the alveoli and is then exhaled out of the body.**

As air moves through the respiratory system, it is warmed, moistened and filtered. Many of the cells lining the respiratory system produce a thin layer of protective mucus. This layer also traps inhaled particles of dust and smoke. Cilia lining the passageways then sweep such materials away from the lungs, keeping them clean and open for the important work of gas exchange.

Respiration is achieved through the mouth, nose, ***pharynx***, ***trachea***, lungs, and ***diaphragm***. Oxygen enters the respiratory system through the mouth and the nose. After being filtered, warmed and moistened, the air enters the *pharynx.* The oxygen then passes through the ***larynx*** (where speech sounds are produced) and the *trachea*, which is a tube that enters the chest cavity. There, the trachea splits into two smaller tubes called the ***bronchi***. Each *bronchus* then divides again, forming the bronchial tubes. The bronchial tubes lead directly into the lungs where they divide into many smaller tubes, called ***bronchioles***, which connect to tiny sacs called ***alveoli***.

Alveoli are tiny air sacs that have the appearance of grape-like clusters. The average adult's lungs contain about 600 million of these spongy, air-filled sacs that are surrounded by capillaries. The *inhaled* oxygen passes into the alveoli and then diffuses through the capillaries into the arterial bloodstream. Meanwhile, the waste-rich blood from the veins releases its carbon dioxide into the alveoli. The carbon dioxide follows the same path back out of the lungs when you *exhale*.

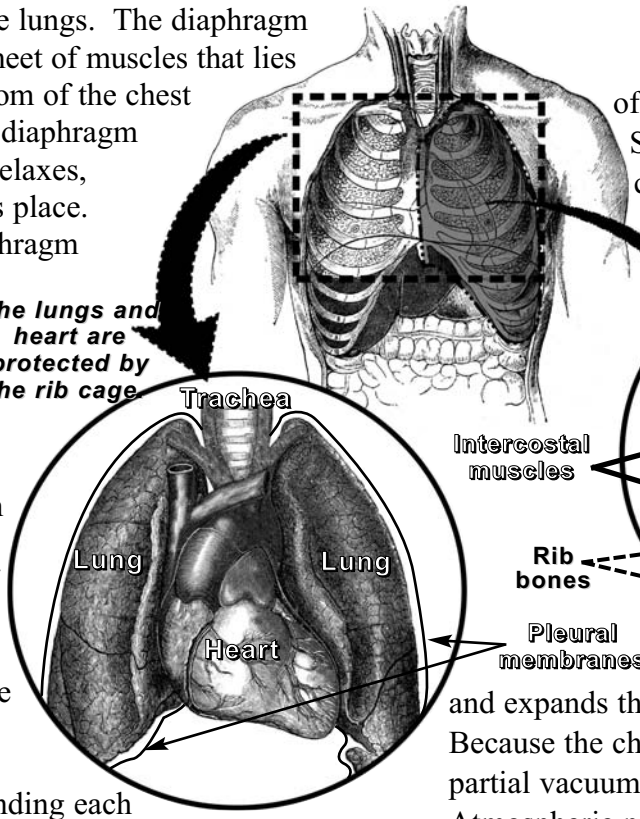
Intercostal muscles are responsible for causing the chest cavity to expand when air is inhaled and get smaller when air is exhaled.

The *diaphragm's* job is to help pump carbon dioxide out of the lungs and pull

### VOCABULARY

***Bronchi***: air tubes that enter the lungs and branch off for gas exchange; bronchial tubes
***Bronchiole***: one of many very small air passageways that branch from the bronchi
***Alveoli (singular, alveolus)***: tiny air sacs in the lungs surrounded by a network of capillaries where gas exchange takes place

oxygen into the lungs. The diaphragm consists of a sheet of muscles that lies across the bottom of the chest cavity. As the diaphragm contracts and relaxes, breathing takes place. When the diaphragm contracts, oxygen is pulled into the lungs. When the diaphragm relaxes, carbon dioxide is pumped out of the lungs. The process of gas exchange in the lungs is very efficient.

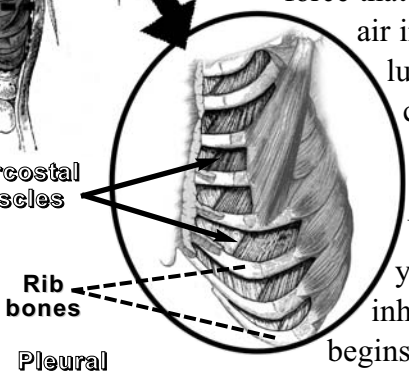



Surrounding each lung, and lining the chest cavity, is the *pleural membrane*—a tissue consisting of two thin layers. The area between the membrane and lung is called the *pleural space*. Amazingly, the total surface of internal lung membranes can be as great as 1,700 feet, or about half of a tennis court in size! Equally amazing is the fact that a small hole in the pleural membrane can result in a number of medical emergencies, including a collapsed lung.

The air that you *inhale* contains 21 percent oxygen and .04 percent carbon dioxide. *Exhaled* air is usually less than 15 percent oxygen. This means that the lungs remove about one third of the oxygen in the air that you inhale and increase the carbon dioxide content of that air by a factor of 100. The molecule *hemoglobin* is responsible for much of the system's efficiency. Hemoglobin's affinity for oxygen is so great that it increases the oxygen-carrying capacity of the blood more than 60 times.

## BREATHING

Breathing is the movement of air in and out of the lungs. Surprisingly, no muscles are connected to the lungs to help with this movement. The force that drives air into the lungs comes from air pressure. When you inhale, air begins to rush in. The diaphragm contracts and expands the volume of the chest cavity. Because the chest cavity is tightly sealed, a partial vacuum is created inside the cavity. Atmospheric pressure does the rest, filling the lungs.




Most of the time, exhaling is a passive event. When the diaphragm muscle relaxes, elastic tissues surrounding the chest cavity return to their original positions, placing pressure on the lungs. As a result, air rushes back out. As you know, sometimes you exhale with much greater force, as when you blow out a candle. Muscles surrounding the chest cavity provide that extra force, contracting vigorously as the diaphragm relaxes.

Normally, you can only hold your breath for a maximum of five or six minutes, which of course denies the body the gas exchange process. However, your chest will begin to feel tight, your throat will start to burn, and the muscles in your mouth and throat will struggle to keep from breathing. Finally, a person's body will force him to breathe or the person will die, as some teens

have discovered in staging unwise "breath-holding contests."

Breathing is such an important function that your nervous system will not let you have complete control over it. The brain controls this process in a breathing center located in the *medulla oblongata*—a part of the brain just above the spinal cord. Cells in this breathing center monitor the amount of carbon dioxide in the blood. As the carbon dioxide level increases, nerve impulses from this center cause the diaphragm to contract which brings air into the lungs. When the carbon dioxide level becomes dangerously high, the impulses to breathe become so powerful that most persons cannot resist breathing.

**In the next lesson, we will continue our study of the respiratory system by studying the common cold and the hazards of smoking.**

***Career Bound?***

Emergency Medical Technicians (EMTs) are trained to evaluate injuries and provide appropriate first aid care. Certification in CardioPulmonary Resuscitation (CPR) and advanced first aid is required for EMT certification.

# LIFE PRINCIPLE



**"...in the final analysis, our most basic, common link is that we all inhabit this small planet, we all breathe the same air...and we are all mortal."**

—John F. Kennedy (1917-1963)
Speech at The American University, Washington, D.C., June 10, 1963



The Human Body

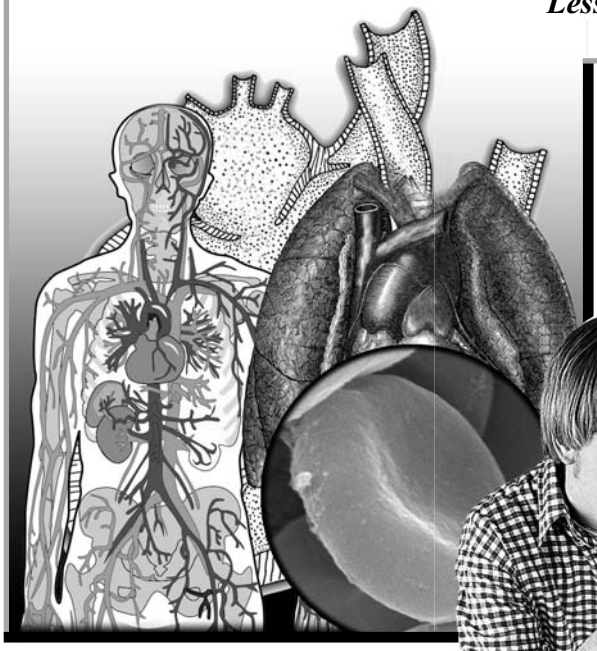
Lesson 5

# Chapter 2

## THE HUMAN BODY: THE RESPIRATORY SYSTEM—VARIOUS HAZARDS

### Section 1

*Lessons 1-5*

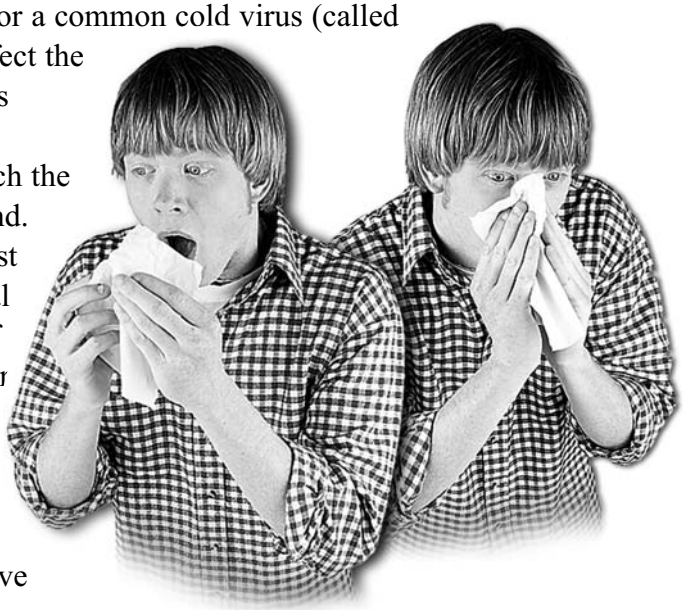


### The Common Cold

Nine out of ten Americans experience the "common cold" each year. Many of those suffering from colds are teenagers, who "catch" an average of six colds per year. According to recent statistics, this translates into about 26 million school days missed by students in the United States each year!

Students are especially susceptible to colds when they are around others who are breathing out germs as well as coughing and sneezing into the air. A forceful sneeze has been measured to travel nearly 100 miles per hour! Other symptoms of the common cold include nasal congestion and/or the sniffles. Viruses and some bacteria cause most colds. Younger students are more susceptible to colds because they frequently congregate and touch each other's hands as well as share food and drinks back and forth among themselves.

In order for a common cold virus (called *rhinovirus*) to infect the body, it must pass beyond the nasal passages and reach the pharynx or beyond. Rhinoviruses must attach to the nasal epithelial cells of the throat in order to multiply and infect. The respiratory system is lined with cells that have



## VOCABULARY

***Carcinogenic***: cancer-causing substances

***Metastasis***: the spread of a disease (usually cancer) from an original site of infection to other parts of the body

***Arteriosclerosis:*** a chronic disease in which artery walls thicken and harden, causing loss of artery elasticity

cilia, which are tiny, hair-like projections that extend from the cell membrane. These ciliated cells secrete mucus that traps heavy particles of microbes. Each cell has several hundred cilia. The cilia beat in synchrony to push mucus up the throat for expulsion. This upward action moves air pollutants, tobacco particles, and pathogenic bacteria that may have been inhaled and stuck in the mucus.

The common cold is more prevalent during the fall and winter, due partly to cold weather for which one is inadequately dressed and increased sugar consumption associated with winter holidays—both of which tend to lower one's immune system.

Rhinoviruses disturb the upper respiratory system and grow in the nose, where the temperature is a few degrees cooler than the rest of the body. (This is why the Greek term "rhinos", meaning *nose*, is used to describe these viruses.) You keep catching the common cold because so many rhinoviruses exist. Your body can build immunity against one virus at a time. Unfortunately, many hundreds exist. Senior adults eventually develop antibodies to about 55 percent of rhinoviruses. Most humans spend a lifetime building immunity to the majority of cold viruses. You can help reduce the number of colds you have by keeping your immune system healthy. This means getting plenty of rest, eating nutritiously, and distancing yourself from persons with rhino symptoms. Frequent hand washing, especially before eating and after toilet use, also helps reduce the spread of viruses (and bacteria).

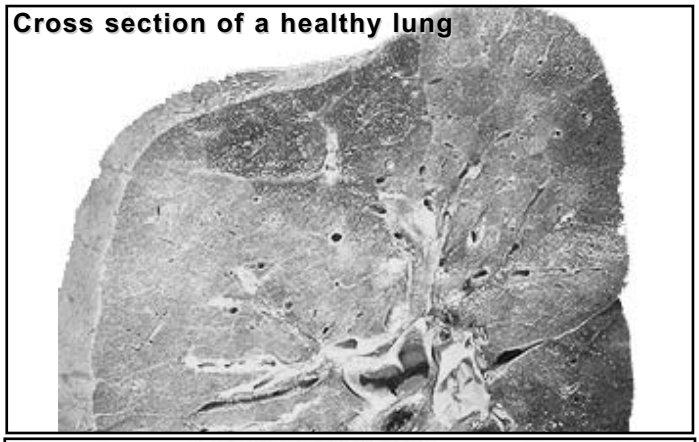
## Asthma

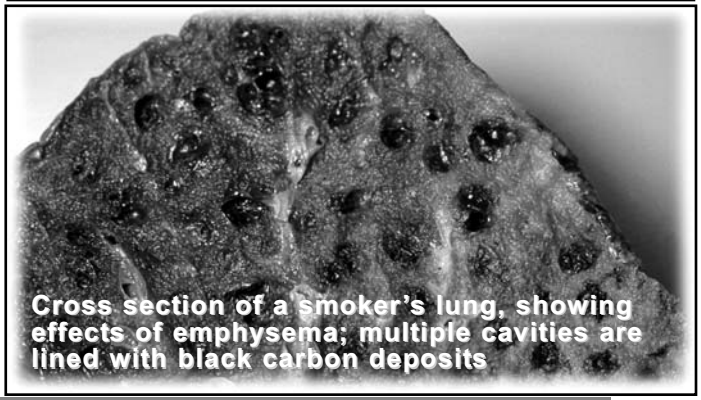
Asthma is a potentially fatal respiratory disorder which affects young people. Some experts believe various factors may be at fault, such as emotional trauma associated with breakup of the family and tobacco smoke (both first and second-hand types). Air pollution is another explanation for the increasing incidence of asthma. Although industrial air pollution has declined somewhat over the past few decades, much more pollution exists from motor vehicle exhaust in urban areas.

## Smoking

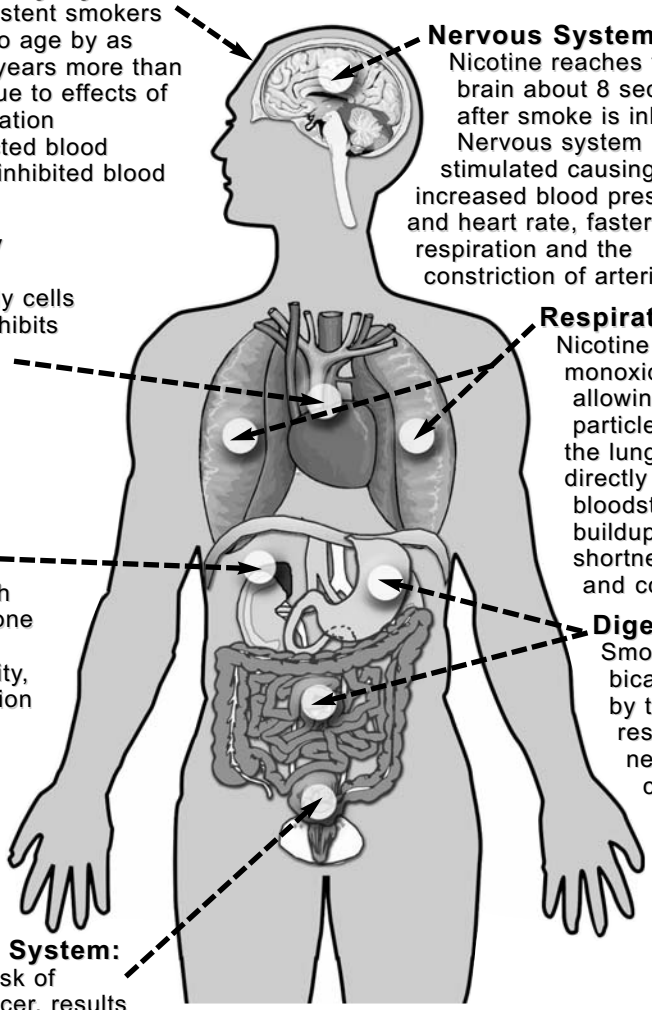
Inhaling tobacco smoke damages the respiratory system. The passageways may be blocked, the lungs damaged, and other gases from tobacco can interfere with hemoglobin.

Tobacco contains numerous harmful chemical compounds, including carbon monoxide, nitrogen oxides, hydrogen cyanide and ammonia. When tobacco burns, toxic compounds are released. Three of the most dangerous compounds produced by tobacco smoke are tar, carbon monoxide, cadmium


Cross section of a healthy lung


Cross section of a smoker's lung, showing effects of emphysema; multiple cavities are lined with black carbon deposits

## Some Effects of Smoking on the Systems of the Human Body




and nicotine. When tobacco smoke is inhaled, these substances quickly enter the airways and bloodstream of the human body.

As you have learned, the upper part of the respiratory system is generally able to filter out dust and foreign particles that might otherwise damage the system. However, nicotine and carbon monoxide paralyze the cilia. With the cilia out of order, the inhaled particles stick to the walls of the respiratory tract or enter the lungs. The paralyzing effects of just one cigarette can last up to an hour. Because of these effects, smoking tobacco products can cause an increase in the number of colds experienced by people who smoke.

In response to the irritating effects of cigarette smoke, the respiratory system increases mucus production. Without cilia to sweep it along, the mucus builds up and obstructs the airways. This explains why smokers often cough in order to clear their airways. Smoking also results in the swelling of the lining of the respiratory tract, resulting in less air-flow to the alveoli. Tar accumulates in the lungs where it passes directly to the blood-stream. Researchers have found a number of compounds in tar that may be ***carcinogenic***.

Smoking can lead to respiratory disorders such as pneumonia, bronchitis, emphysema and lung cancer. In bronchitis, the bronchi become clogged with mucus. In pneumonia, the lungs are affected and weakened. People with bronchitis or pneumonia often find simple physical activities very difficult, such as climbing stairs or walking a distance. Emphysema involves a loss of elasticity in the tissue of the lungs, making breathing very difficult. People with emphysema can neither get enough oxygen nor sufficiently offload the toxic carbon monoxide. Lung cancer is the most serious consequence of smoking. Nearly 180,000 people in the United States develop lung cancer every year. Most of

these do not survive. Lung cancer spreads quickly as small groups of cancer cells from the lungs break off and spread to other places in the body. This process is called ***metastasis***. By the time lung cancer is detected, it usually has spread to many other places in the body. Lung cancer claims 87 percent of its victims in the first five years after it is detected.

Smoking particularly affects the circulatory system. People who smoke have twice the rate of heart disease as do non-smokers. The circulatory system is most affected by the nicotine and carbon monoxide found in tobacco smoke.

Carbon monoxide (CO) is a highly poisonous gas and has a higher affinity to hemoglobin than does oxygen. This means that CO binds tightly to hemoglobin, taking valuable space that is meant for oxygen. As more carbon monoxide combines with hemoglobin, the oxygen-carrying capability of blood is reduced drastically. As a result, the heart must work harder in order to deliver oxygen to the body cells. People who smoke are literally starving their body cells of oxygen!

The nicotine in cigarettes causes blood vessels to constrict, thus inhibiting blood flow. It also causes a rise in the resting heart rate which makes the heart work even harder than normal. Additionally, nicotine causes blood pressure to rise.

Smoking seems to increase the buildup of fatty substances on the walls of blood vessels. This buildup leads to the development of ***arteriosclerosis***, also known as *hardening of the arteries*.

Smoking affects other body systems as well. Nicotine is a stimulant drug with similar effects of other stimulant drugs, especially on the nervous system. In addition, smoking adversely affects the digestive system, the endocrine system and the excretory system.

The best policy with regard to smoking is never to begin. Smoking is a very hard habit to break, and research has shown clearly that smoking is extremely hazardous to human health and quality of life. Smoking is an expensive practice that costs the lives of thousands of people annually.

**In the next lesson, we will begin a study of the digestive and excretory systems by examining the importance of nutrition.**

***Career Bound?***

A respiratory therapist is responsible for administering respiratory care and life support to cardiopulmonary patients, either under the supervision of a physician or by prescription from a physician. For example, a respiratory therapist might educate patients on the proper use of an atomizer that delivers asthma medication.

# LIFE PRINCIPLE



**"Never open the door to a little vice, lest a great one should enter too."**

—Henry C. Blinn
In *Simple Wisdom* by Kathleen Mahoney



The Human Body

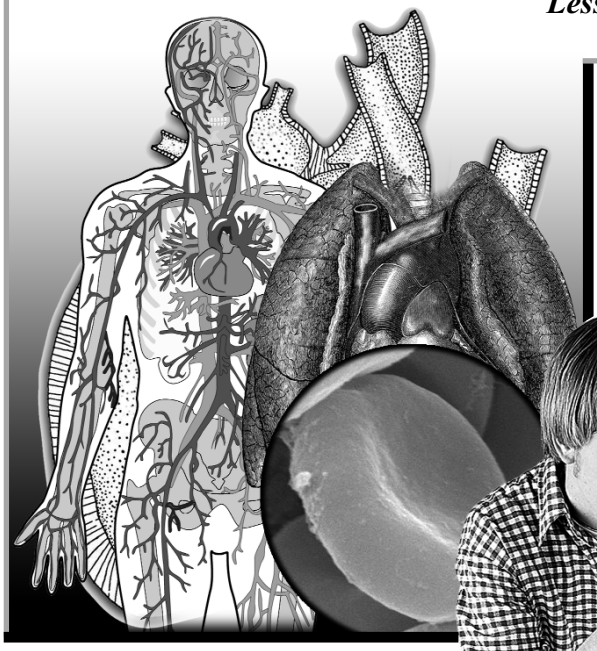
**Lesson 5**

# *Chapter 2*

## Section 1

***Lessons 1-5***

## *THE HUMAN BODY: THE RESPIRATORY SYSTEM—VARIOUS HAZARDS*

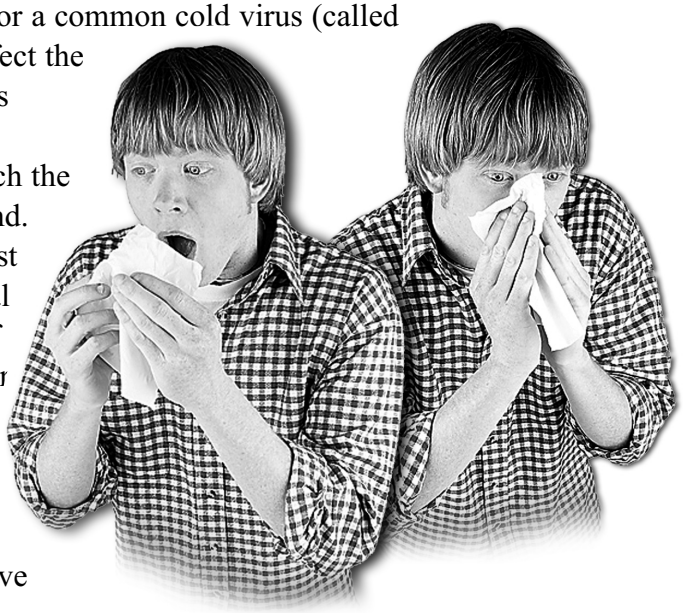


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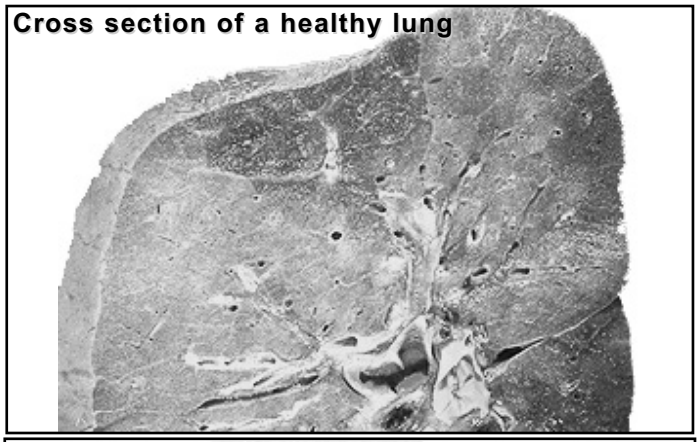
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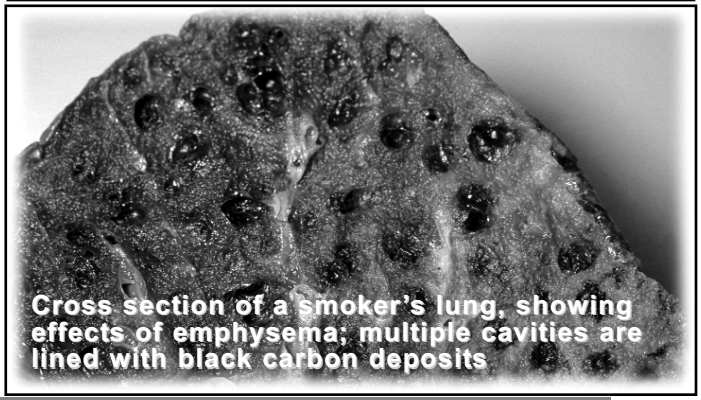
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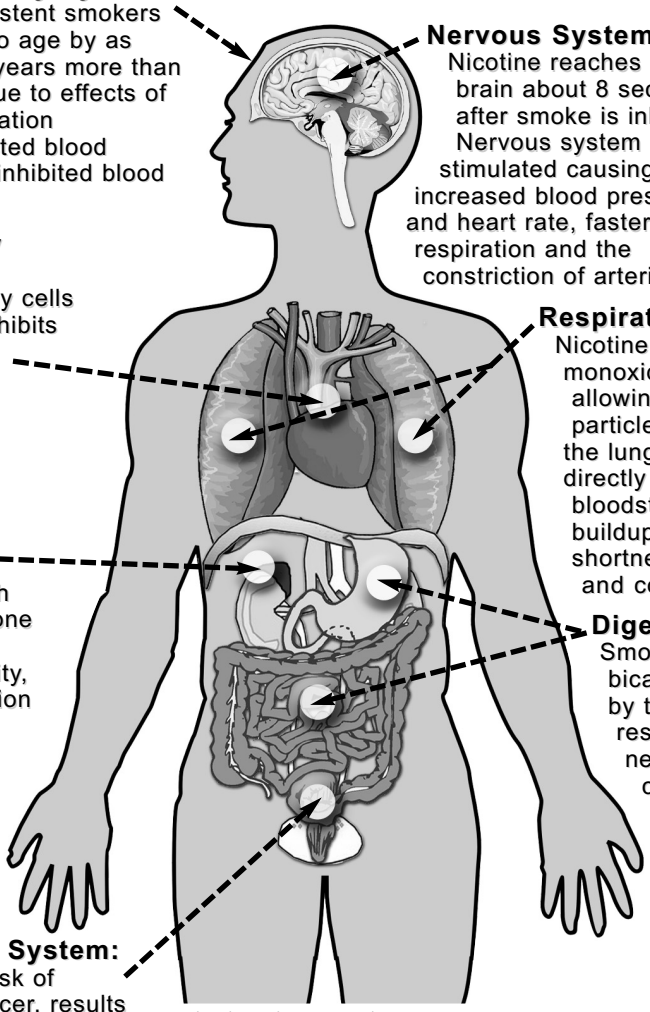
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Carbon monoxide (CO) is a highly poisonous gas and has a higher affinity to hemoglobin than does oxygen. This means that CO binds tightly to hemoglobin, taking valuable space that is meant for oxygen. As more carbon monoxide combines with hemoglobin, the oxygen-carrying capability of blood is reduced drastically. As a result, the heart must work harder in order to deliver oxygen to the body cells. People who smoke are literally starving their body cells of oxygen!

The nicotine in cigarettes causes blood vessels to constrict, thus inhibiting blood flow. It also causes a rise in the resting heart rate which makes the heart work even harder than normal. Additionally, nicotine causes blood pressure to rise.

Smoking seems to increase the buildup of fatty substances on the walls of blood vessels. This buildup leads to the development of ***arteriosclerosis***, also known as *hardening of the arteries*.

Smoking affects other body systems as well. Nicotine is a stimulant drug with similar effects of other stimulant drugs, especially on the nervous system. In addition, smoking adversely affects the digestive system, the endocrine system and the excretory system.

The best policy with regard to smoking is never to begin. Smoking is a very hard habit to break, and research has shown clearly that smoking is extremely hazardous to human health and quality of life. Smoking is an expensive practice that costs the lives of thousands of people annually.

**In the next lesson, we will begin a study of the digestive and excretory systems by examining the importance of nutrition.**

***Career Bound?***

A respiratory therapist is responsible for administering respiratory care and life support to cardiopulmonary patients, either under the supervision of a physician or by prescription from a physician. For example, a respiratory therapist might educate patients on the proper use of an atomizer that delivers asthma medication.

# LIFE PRINCIPLE



**"Never open the door to a little vice, lest a great one should enter too."**

—Henry C. Blinn
In *Simple Wisdom* by Kathleen Mahoney



The Human Body

Lesson 6

# Chapter 2

## Section 2

*Lessons 6-10*

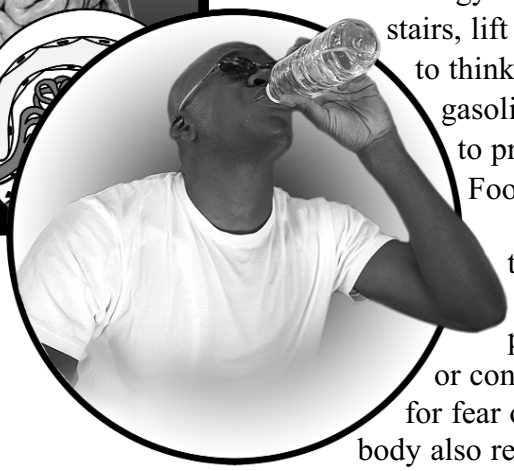
## THE HUMAN BODY: THE DIGESTIVE SYSTEM—NUTRITION



To most people, food is more than just nourishment. Food is an important part of culture. Human societies around the globe organize meetings and family gatherings around certain kinds of foods.

The body's need for food is exceeded only by its need for oxygen and water. Nutritious food is necessary to attain and maintain health and strength. Food gives the body energy and, thus, the ability to do work.

You need energy to walk to class, climb up stairs, lift books, exercise and even to think. Like a car that needs gasoline, your body needs fuel to produce energy to work. Food is fuel for the body.



A car also requires the right kind of fuel. You would not intentionally put the wrong kind of fuel, or contaminated fuel, in your car for fear of ruining the engine. The body also requires the right kind of food to operate properly. The foods that we eat not only provide us with the energy to perform various types of functions, they also contain the materials from which body cells and tissues are made.

The energy available in food can be measured by the amount of heat the food produces and is expressed in terms of *calories*. A ***calorie*** in physics has a different meaning than a food calorie. On packaged foods, nutrition labels use the *unit calorie*, which really represents 1000 calories or one *kilocalorie* (kcal). Thus, a teaspoon of sugar contains 16,000 calories or 16 kilocalories.

The basic energy needs of an average teenager are between 1500 and 1600 kcal per day. If you are involved in vigorous sports, your energy needs may be higher.

### VOCABULARY

***Calorie***: amount of heat energy needed to raise the temperature of one gram of water by one degree Celsius

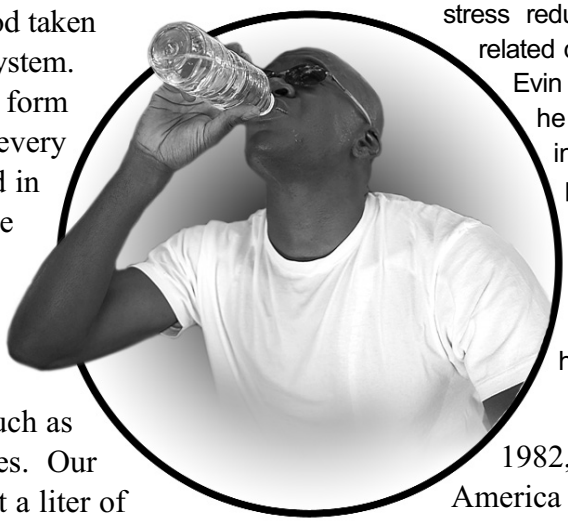
***Enzymes:*** complex protein substances produced in living cells of plants and animals; cause or accelerate chemical changes in the body without being permanently changed themselves

***Metabolic:*** pertaining to chemical changes in living cells by which energy is provided for vital life processes and activities, and by which new material is assimilated

The body is able to manufacture many of the molecules needed for life. However, the body obtains most of its nutrients from ingested food. Nutrients needed by the body are water, carbohydrates, fats, proteins, vitamins, minerals and enzymes.

## WATER

As you may recall, water is needed by every cell in the body and makes up the bulk of the blood, lymph and other body fluids. Water dissolves food taken into the digestive system. Water is lost in the form of sweat, vapor in every exhaled breath, and in urine. Water can be replaced by drinking pure water and by eating moisture-containing foods such as fruits and vegetables. Our bodies need at least a liter of water a day to replace that which is lost. Dehydration can result when people do not intake sufficient quantities of water. This leads to problems in the circulatory, respiratory and nervous systems which can lead to hospitalization.



Since our bodies are more than two-thirds water, one could logically conclude that water has medicinal value to keep the body machinery operating properly; however, the obvious is often overlooked. For one medical doctor, prison tap water was his only means of treating disease. Imprisoned during the Iranian Revolution of 1979, Dr. Batmanghelidj was forced to treat fellow inmates using the only resource available—water. The book, *Your Body's Many Cries for Water*, tells of "Dr. Batman's" discovery:

> One late night at the beginning of his incarceration at Evin prison, Dr. Batmanghelidj discovered the medicinal value of water in peptic ulcer disease when, in place of medications he did not possess at the time, he had to prescribe two glasses of water to an ulcer patient in extremely severe abdominal pain. Within eight minutes the pain disappeared and, according to him (Dr.B), a new era of advancement of medical science was born. For the next 25 months, he became completely engrossed in clinical research of the medicinal values of water in stress reduction and treatment of stress-related disease conditions of the body in Evin prison....His trial time came, and he had to answer 32 fictitious indictments carrying the death penalty. As his final defense, he presented the judge with an article on water treatment of peptic ulcer disease. His life was spared so that he could continue his research.

Released from prison in 1982, Dr. Batmanghelidj escaped to America to do further research and share his discoveries with medical/scientific communities in the United States.

Clearly, drinking plenty of pure water is one of the best things you can do to keep your body healthy.

## CARBOHYDRATES

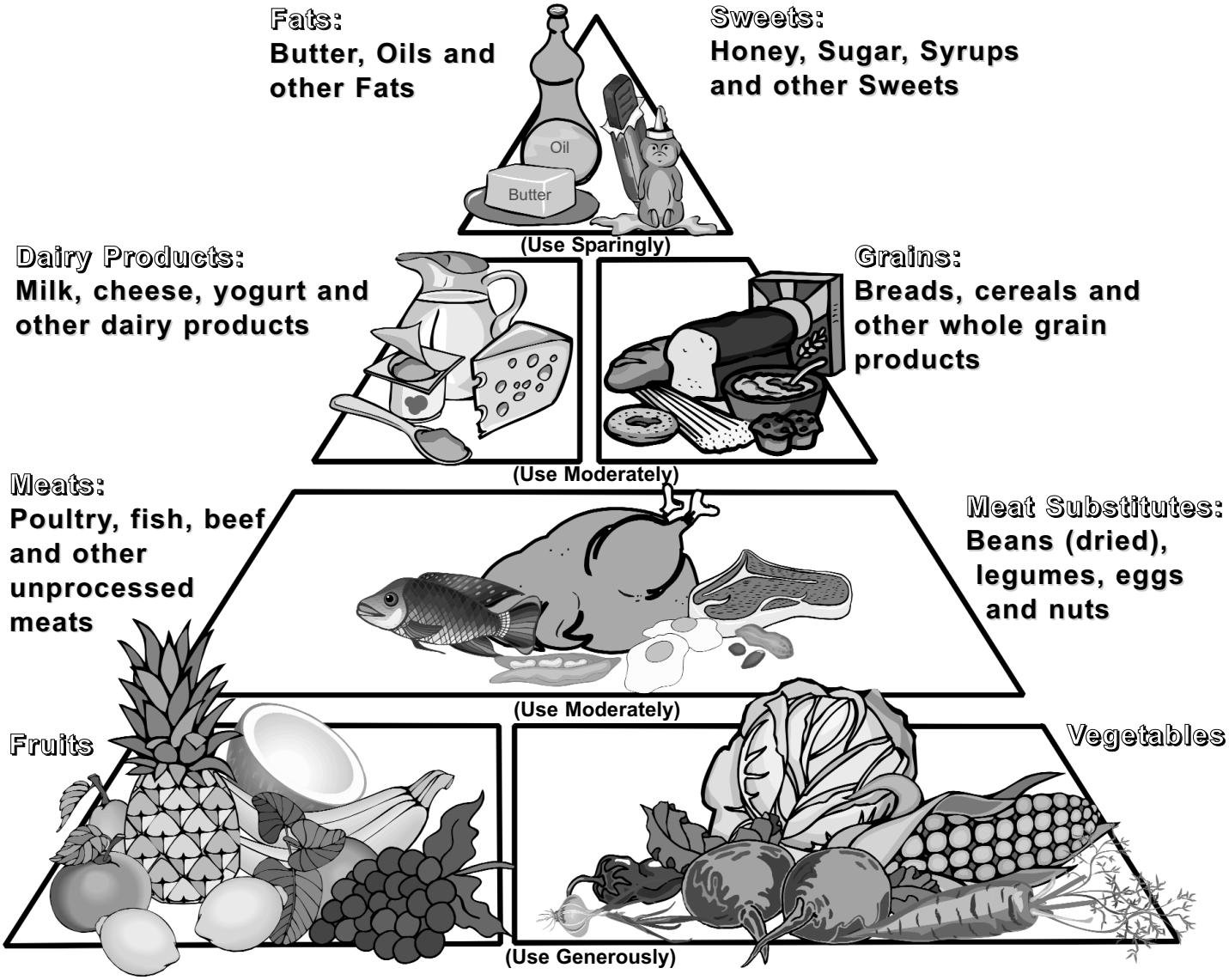
Carbohydrates are major sources of energy. Sugars, such as found in fruits, honey, sugar cane and sugar beets are examples of *simple carbohydrates*. Starches found in grains, potatoes and other vegetables are examples of *complex carbohydrates*. Starches must be broken down by digestive enzymes into simple sugars before passing into the bloodstream. Simple sugars provide energy to cells throughout the body. Many carbohydrate-rich foods also contain cellulose,

known as *fiber*. Unlike starch, the sugars in cellulose are linked together in such a way that humans and many other animals cannot utilize them as energy. Cellulose does add bulk to the diet and thereby aids in moving materials through the digestive system. The bulk helps the muscles of the digestive system process foods more effectively. Foods such as raw carrots, whole grain bread and bran are rich in fiber. Standard white sliced bread does not serve as a digestive aide because most of the nutrients have been removed by processing. The term *enriched* on the label simply means that the producers have added only a small percentage of nutrients back into the product.

### Fats

Unfortunately, "fast foods" have introduced bad fats into modern culture. Thus, fats have a bad reputation in today's society. Fast foods are usually prepared with processed oils or animal fats which place excessive amounts of bad fats into the human digestive system. Good fats are very

## A Food Guide Pyramid



| Vitamins Essential to the Human Body | | | |
|---|---|---|---|
| **Water-soluble Vitamins (not stored in the body)** | | | |
| ***Label/Name*** | ***Sources*** | ***Functions/Uses*** | ***Consequences of vitamin deficiency*** |
| $B_1$ (thiamine) | Whole grains, legumes, liver, yeast | Nerve function; coordination of muscles; coenzyme for carbohydrate metabolism | Beriberi, heart damage, sluggish behavior, emotional disturbances |
| $B_2$ (riboflavin) | Eggs, dairy products, raw vegetables, liver | Necessary for releasing energy to cells, metabolizing of foods and proper functioning of vitamins $B_3$ and $B_6$ | Cracked skin and sores around nose and mouth, behind ears and upper edges of fingernail bed |
| $B_3$ (niacin) | Grass-fed red meats, free-range poultry, liver, mushrooms | Necessary in the conversion of food to energy and maintenance of digestive tract and nervous system | Pellagra, mental disturbances, disorders of the skin and intestines, diarrhea |
| $B_5$ (pantothenic acid) | Whole grains, liver, range-fed meats, eggs | Necessary in Krebs cycle and in the manufacturing of adrenal hormones | Insufficient hormone production; reproductive complications |
| $B_6$ (pyridoxine) | Whole grains, liver, dairy products, broccoli, bananas | Protein and amino acid metabolism; assists in the forming of red blood cells | Anemia, itchy and scaly skin; muscular spasms |
| $B_7$ (biotin) | Intestinal bacteria, liver, raw vegetables, yeast, egg yolk | Necessary in forming certain fatty acids and metabolizing glucose | Disorders of skin and hair; anorexia, muscle pains; nervousness |
| $B_9$ (folic acid) | Eggs, legumes, liver, whole grains, sprouts, green vegetables | Necessary for protein metabolism, formation of red blood cells and the manufacturing of genetic material | Anemia; impaired growth; inhibits cell formation; intestinal problems; adverse effects during pregnancy |
| $B_{12}$ (cyanocobalamin) | Range-fed meats, dairy products, eggs | Assists in forming red blood cells; constructs genetic material | Pernicious anemia; neural and nervous disorders; nerve damage |
| C (ascorbic acid) | Leafy green vegetables, potatoes, citrus fruits, tomatoes | Fortifies blood vessel walls, aids in binding cells together, assists in iron absorption; antioxidant | Scurvy; weak muscles; easy bruising; bleeding gums; skin lesions |
| Choline | Whole grains, beans, liver, egg yolks | Necessary for neurotransmitters and phospholipids | Muscular damage; adverse effects during pregnancy |
| **Fat-Soluble Vitamins (can be stored in the body)** | | | |
| A (retinol) | Orange and yellow fruits and vegetables, liver, butter | Necessary for maintaining healthy eyes, teeth, hair and skin; enables proper functioning of immune system | Night blindness; poor eyesight; vulnerable to infection; rough, dry skin |
| D (calciferol) | Exposure to sun, fish oils, egg yolk | Necessary for calcium absorption and building strong bones and teeth | Rickets; malformation of bones; osteoporosis |
| E (tocopherol) | Brown rice, meats, nuts, butter, seeds, leafy vegetables | Assists in formation of muscular tissues and red blood cells; antioxidant; works to preserve essential fatty acids | Nerve abnormalities; slight case of anemia |
| K (phylloquinone) | Liver, leafy vegetables, intestinal bacteria | Necessary in proper blood clotting | Internal hemorrhaging; complications in blood clotting |

important in our diets. Your body needs certain essential fatty acids to manufacture the lipid membrane of each cell and for the production of certain hormones. Fat needs vary from person to person. Growing, active teenagers need more fat than do middle-age, inactive adults. Good fats are found in foods such as nuts, butter (not margarine), coconut oil, olives and olive oil, fish and fish oil and avocados.

## Proteins

Proteins are important nutrients because they are composed of amino acids, the building blocks for new cells and tissues. Rapidly growing tissue, including that of the skin and the lining of the digestive system, must constantly replace dead and dying cells with new ones. Of the 22 most common amino acids, your body is able to make fourteen. The other eight must be obtained from foods and are thus called *essential amino acids*.

Good sources of healthy proteins are fish, free-range poultry, grass-fed beef, eggs, cheese, yogurt, beans, legumes and nuts.

Diets deficient in protein hamper cell growth and can cause serious health problems. On the other hand, too much protein can also cause health concerns such as kidney problems, bowel problems and excess weight gain.

**Minerals**

| Names/Labels | Sources | Functions/Uses | Consequences of mineral deficiency |
|---|---|---|---|
| Calcium | Dark-green vegetables, milk, yogurt, legumes, sardines | Builds strong bones and teeth; healthy nerve and muscle function; assists in blood clotting and activation of enzymes necessary in converting food to energy | Weak bones; stunted growth |
| Phosphorus | Dairy products, egg yolks, poultry, nuts | Necessary for metabolism, proper nerve and muscle function; works with calcium in building bones | Depletion of bone minerals; weak bones; anorexia |
| Potassium | Most vegetables and fruits; peanuts, sunflower seeds | Helps balance acids and bases; necessary for proper nerve and muscle functions | Heart complications; muscular weakness |
| Sodium | Table salt, celery | Helps balance acids, bases and fluids; necessary in nerve and muscle function | Muscular spasms; diarrhea; overall weakness |
| Magnesium | Green vegetables | Enzyme activator; necessary in cells for bone growth and genetic materials | Muscular cramping and spasms; irregular heartbeat; nausea |
| Iron | Liver, leafy vegetables, whole grains, lean meats, beets, apricots, raisins | Necessary in the production of hemoglobin; essential element in the blood for carrying oxygen to cells | Anemia; overall weakness; skin pallor |
| Iodine | Seafood, dairy products | Necessary for proper thyroid function | Enlarged thyroid |
| Zinc | Whole grains, beans, turkey, beef, peanuts | Essential element in over 100 enzyme reactions necessary to metabolism and digestion | Wounds heal slowly; stunted and delayed growth |

## Vitamins, Minerals, Enzymes

While proteins, fats and carbohydrates build and maintain the body, vitamins and minerals are the tools that help put them together. *Vitamins* are organic molecules that the body needs to help perform important

chemical reactions. Although vitamins are needed in very small quantities, vitamin deficiencies can have serious and sometimes fatal results.

Fourteen vitamins are now recognized as essential to human health. Scientists believe that more have yet to be discovered. Eating a diet containing a wide variety of wholesome, fresh foods will supply the daily vitamin needs of most people. However, daily nutritional supplements may be needed by people with a history of poor eating habits. People who want to rebuild health make sure they have adequate daily intake of essential vitamins, such as A, C, D, E and B-complex.

*Minerals* are inorganic substances in the soil that are made organic and usable through their uptake by plants and are needed in very small amounts by the body. Calcium, for example, is required to produce the calcium phosphate that makes up bones and teeth. Iron is needed to make hemoglobin. Iodine is required to synthesize thyroxin, a very critical hormone for the thyroid gland and general functioning of the body.

***Enzymes*** are catalizing agents upon which our very lives depend. The human body is set up to utilize over 3,000 different enzymes, each designed for a specific task. Three important classifications of enzymes exist:

1. ***Metabolic*** *enzymes* assist our mental and sensory systems and aid in repairing damaged tissue.

2. *Digestive enzymes* are tasked with digesting and assimilating the foods we eat. For example, *protease*, *trypsin* and *chymotripsin* break down animal proteins; *lactase* breaks down milk protein; *amylase* breaks down certain carbohydrates, and *lipase* breaks down fats.

3. *Immune/defence enzymes* are responsible for helping defend the body against inflammation; invading microbes, other foreign substances and unhealthy conditions.

Over 200 illnesses appear to result from the lack of certain enzymes. For example, people with cystic fibrosis have been shown to be deficient in the enzymes *lipase* and *trypsin*. Supplemental enzymes have the ability to increase bacteria-destroying macrophage activity by 700 percent.

Vitamin, mineral and enzyme supplements are available at food stores and pharmacies. However, indiscriminately taking vitamin/mineral supplements does not always benefit the body. Each person has unique nutritional needs. For example, one person may take a large dose of one vitamin that causes another vitamin or mineral to become imbalanced. Yet that same dose may be needed by another person with a different body metabolism.

However, good eating habits are always wise for everyone. A general recommendation, known as the Food Pyramid, is shown in this lesson. Recommended amounts for each category change periodically as new information becomes popular. The basic idea is simple: you should try to get a wide variety of fresh foods each day, as close to their natural state as possible, and reduce sugar intake (sugar inhibits your immune system). Good eating habits help maintain good health.

**In the next lesson, we will examine the digestive system and its functions.**

# LIFE PRINCIPLE



**"In large measure, we are spiritually what we believe, emotionally what we think, and physically what we eat."**

—Anonymous



The Human Body

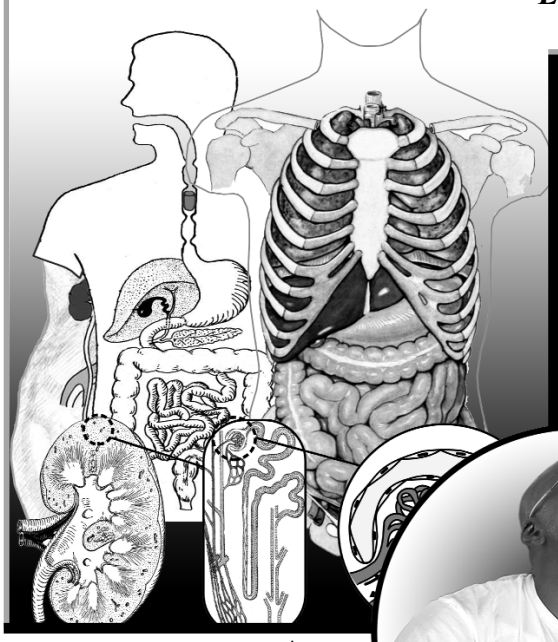
Lesson 7

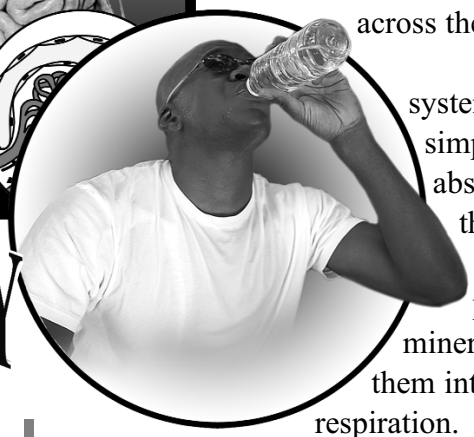
# Chapter 2

## THE HUMAN BODY: THE DIGESTIVE SYSTEM—FUNCTION

## Section 2

***Lessons 6-10***





## VOCABULARY

***Epithelia***: cells forming a thin tissue lining of body surfaces

***Lysozyme***: saclike membrane filled with chemicals and enzymes that can break down almost any substance within a cell

***Epiglottis***: flap of tissue that prevents food from entering the trachea (air passageway)

***Esophagus***: tube through which food passes from the pharynx to the stomach

***Peristalsis***: muscular contractions that pass food through the alimentary canal or digestive tract

The human digestive system is a long tube—an alimentary canal-- with an opening at each end and many specialized organs in between. If the tube of an adult were fully stretched, it would extend 21 to 30 feet. From beginning to end, mucus coated ***epithelia*** line all the surfaces facing the *lumen* (the space within the tube). The thick, moist mucus protects the wall of the tube and enhances the diffusion of nutrients across the inner lining.

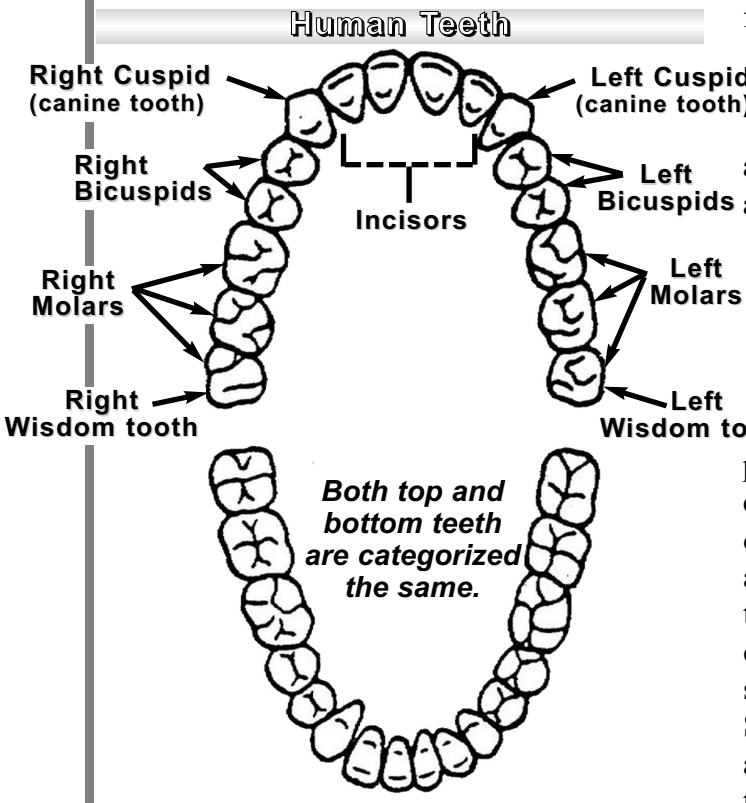
The function of the digestive system is to convert foods into simple molecules that can be absorbed and used by the cells of the body. The digestive system breaks down food into usable proteins, carbohydrates, fats, minerals and vitamins, and converts them into energy during cellular respiration.

The digestive system is designed as 80 percent alkaline and 20 percent acid. Fruits and vegetables are largely alkaline reacting in the body, while grains, meats, dairy products, fats and sweets react with varying degrees of acidity. Chemical digestion of alkaline foods begins in the mouth, skips the stomach, and continues in the small intestine, whereas chemical digestion of proteins begins in the stomach.

### THE MOUTH

Food enters the mouth where the work of the digestive system begins. Food is chewed in order to crush it into a fine paste that can be swallowed easily. The teeth and tongue are aided by saliva in this important breakdown of food. Human teeth are anchored in the jawbones and are connected to each jawbone by a network of blood vessels and nerves that enter through the roots of the teeth. The surfaces of the teeth are

protected by a coating of mineralized enamel—the hardest substance in the body.




## VOCABULARY

***Cardiac sphincter***: thick ring of muscle which closes the esophagus after food has passed into the stomach; prevents the contents of the stomach from moving back

***Pepsin***: protein-digesting enzyme produced by gastric glands in the stomach

***Chyme***: a mixture of stomach fluids and food in the stomach area

***Duodenum***: first part of the small intestine; located between the stomach and the jejunum; mixes secretion from liver, pancreas and gallbladder with chyme from stomach

***Pancreas***: gland located below the stomach that produces digestive enzymes and certain hormones that regulate blood sugar

Teeth do much of the mechanical work of digestion by cutting, tearing and crushing food into small fragments.

Human teeth include 8 *incisors*, which are sharp enough to cut directly through meat and other foods; 4 *cuspids* and 8 *bicuspids*, which grasp and tear food; and 12 *molars*, which have large flat surfaces designed for grinding food. Human tooth structure is designed for a mixed diet of plants and meats.

In the mouth, salivary glands produce an alkaline liquid called *saliva* which helps to moisten the food and to ease its passage through the digestive tract. Saliva contains the enzyme *amylase*, which breaks down starches into sugars. If starchy foods are chewed long enough, they will begin to taste sweet. This is a result of the carbohydrates being broken down into simpler sugars by the action of amylase. Saliva also contains ***lysozymes*** which are anti-microbial substances. Lysozymes help to protect the teeth by fighting bacteria that might attack tooth enamel.

Food is passed from the mouth into the rest of the digestive system by swallowing. Pushed by the tongue and muscles of the throat, the clump of chewed food, called a *bolus*, is forced down the throat. As this happens, a flap of tissue called the ***epiglottis*** closes the opening to the trachea at the back of the throat. This prevents food from getting into the respiratory system.

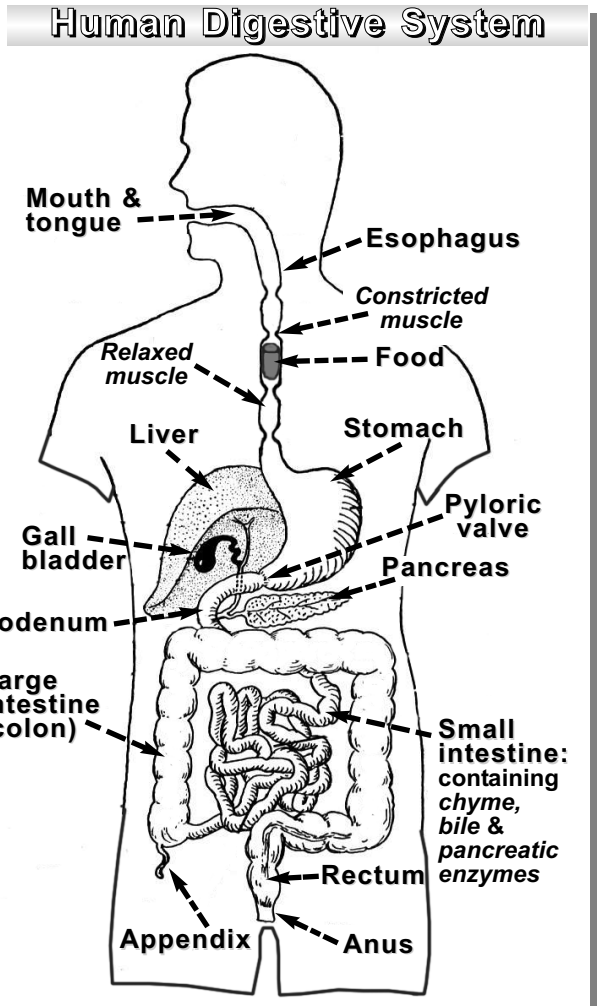
### The Esophagus

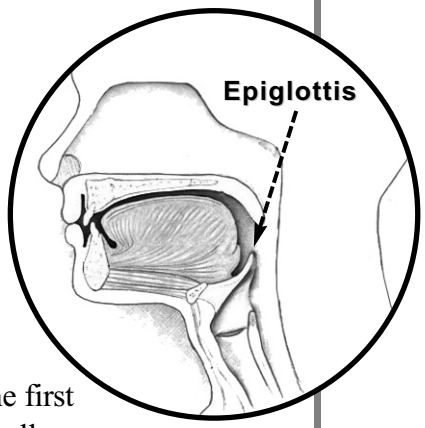
After the bolus is swallowed, it passes through a food tube called the ***esophagus*** into the stomach. Food is moved along by contractions of smooth muscle surrounding the esophagus. These contractions are called ***peristalsis***, which occur throughout the entire alimentary canal to aid in moving food through the system.

## The Stomach

Food passes through the esophagus into a large muscular sac called the *stomach*. A thick ring of muscle, known as ***the cardiac sphincter***, closes the esophagus after food has passed into the stomach. This prevents the contents of the stomach from moving back into the esophagus.

The stomach wall contains millions of microscopic gastric glands that release substances into the stomach. Some of these glands produce mucus, a fluid that lubricates and protects the stomach wall. Other gastric glands produce hydrochloric acid and still other produce ***pepsin***. Pepsin is designed to work at low pH. The stomach contents are normally at a very low pH because of the production of hydrochloric acid. The combination of pepsin and hydrochloric acid in the stomach aid in breaking down proteins. As digestion proceeds, stomach muscles contract to churn and mix stomach fluids and food, gradually producing a mixture known as ***chyme***. After about an hour or two in the stomach, the *pyloric valve*—located in the junction of the stomach and small intestine—opens and chyme is forced into the ***duodenum***.




## The Small Intestine

The *duodenum,* nearly a foot long, is the first of three parts of the small

## VOCABULARY

***Liver***: large gland located above the stomach that produces bile to aid digestion

***Bile***: a mixture of substances containing bile salts, which emulsify fats and aid in their digestion and absorption

***Gallbladder***: organ located just beneath the liver which stores bile and expels bile into the small intestine when it is needed to help digest fats

***Villi***: millions of projections on the folded surfaces of the small intestine that increase the surface area for the absorption of food molecules

***Microvilli***: tiny, fingerlike projections on the surfaces of the cells of the villi

***Lymph vessels***: network of vessels that collects fluid that leaks from the capillaries and returns to the circulatory system

intestine. Here, much of the chemical work of digestion takes place. As chyme enters from the stomach, it is mixed with enzymes and digestive fluids from the ***pancreas***, ***liver*** and ***gallbladder*** (accessory digestive organs), and from the lining of the duodenum itself.

The *pancreas* is an important digestive organ located just below the stomach. One of its functions is to produce hormones that regulate blood sugar. The pancreas also produces the enzymes that break down food. Additionally, the pancreas produces sodium bicarbonate, a strong base that helps to neutralize stomach acid before the chyme enters the duodenum. This is critical for the proper functioning of digestive enzymes.

The *liver* is the largest internal organ of the body and helps with the digestive process. The liver produces ***bile***, a fluid full of lipids and salts. Bile acts as an emulsifier, dissolving and dispersing the fat found in food. Bile enables the enzymes to connect with the fat molecules and break them down efficiently. In the next lesson, we will study the liver in more detail. You will learn more evidence of the intricate and marvelous relationships operative among the human body's organs. Each port functions distinctly, yet in astonishing harmony.

The *gallbladder* is located just below the liver. It is a pear-shaped bag about three inches long. The function of the gallbladder is to concentrate and store bile, which is produced by the liver. The gallbladder expels bile through a duct into the small intestine when it is needed to help digest fats. Pancreatic digestive enzymes also reach the small intestine through the bile duct. Because gallstones are composed largely of cholesterol, too much of the wrong fats in the diet (such as the hydrogenated vegetable oil found in most processed foods) can cause gallstones to form in the liver and in the gallbladder, leading to pain, jaundice and a variety of other symptoms. Gallstones can be dissolved by a variety of methods, including an appropriate mixture of pure olive oil and lemon juice, consumed in a prescribed manner. Doctors often recommend that the gallbladder be surgically removed. This is, of course, the last resort, because removal of any body organ places extra stress and responsibility on the other organs and jeopardizes good health. In the case of the gallbladder, gallstones can still form, even after gallbladder removal.

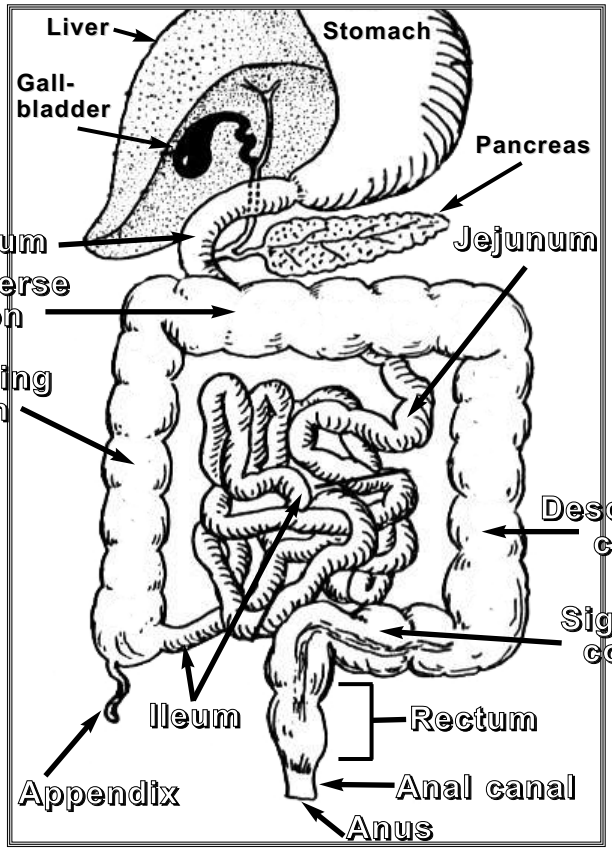
The *jejunum* is the middle portion of the small intestine, measuring some ten to twelve feet long. It is designed as the main site for churning its homogenous mixture, forming intestinal enzymes and absorbing nutrients from the rich mixture of chyme. The inner surface of the small intestine is characterized by circular folds, which not only increase surface area but aid in mixing the chyme. These folded surfaces are covered with some 5,000,000 tiny projections called ***villi***. The surfaces of the cells of the villi are likewise covered with thousands of fingerlike projections known as ***microvilli***. Slow, wavelike contractions of smooth

**Gallstones**
**(size shown in comparison to a quarter)**



muscles move the chyme down the digestive path into the *ileum*, the final part of the small intestine, measuring about fifteen feet in length. Here, remaining nutrient molecules are rapidly absorbed into the cells lining the small intestine. Sugars, amino acids and other nutrients are passed directly into the bloodstream. Fats are transported into the ***lymph vessels*** before entering the bloodstream. Water and electrolytes are absorbed in both the jejunum and the ileum.

As the nutrient-rich blood leaves the small intestine, it passes through the liver before it flows to the rest of the body. The liver monitors the blood before it enters general circulation. In this manner, the liver helps to control blood sugar. The liver removes much of the sugar from the blood coming from the small intestine and stores it in the form of *glycogen* for future use. The liver keeps glycogen in reserve for times when blood sugar levels begin to fall. The human liver can be compared to a community waste treatment plant where impurities are filtered out of the water. The liver is designed to keep the blood supply pure and healthy.




### The Large Intestine

The colon is divided into four main sections: the *ascending colon* (the portion going up from the ileum); the *transverse colon* (the portion going across the abdomen); the *descending colon* (the portion coming back down); the *sigmoid colon* (transversing part of the lower abdomen, connecting to the rectum). The rectum is approximately a five inch tube, continuing from the sigmoid colon to the anal canal (the shortest section of the intestines—about one inch long). The terminal opening of the anal canal is the *anus*.

The *appendix* is a small, fingerlike projection extending down from the lower part of the ascending colon. Until recently, most doctors and scientists regarded the appendix as a useless, infection-prone, vestigal organ from an evolutionary past. However, as medical doctor William Campbell Douglass II pointed out:

> According to new research, the appendix, could act as a reservoir for bacteria called commensal bacteria (that's the kind of bacteria you actually want). Commensal bacteria not only maintain a proper balance in the intestines, but may also kill dangerous microbes. The appendix also boosts the ability of commensal bacteria to survive and repopulate the colon after they're depleted by infection or drug treatment....Everything that we have when we're born was put there for a reason (no matter how long it takes the world's most brilliant scientists to determine what the reason is)....Whatever the appendix is good for, I can guarantee you it's not an

"extra" organ—it's a contributor to your health. And you should hang on to it as long as you can. Just the way God intended....But regardless of how important the appendix may or may not be, one thing's for sure: An infected appendix can be a deadly ailment....Make no mistake: Once an appendix goes sour, it's got to come out. (However) the symptoms of appendicitis need to be thoroughly evaluated before doctors start cutting people open and plucking things out....

Nearly all the available nutrients have been removed from the chyme that enters the large intestine, or colon. The primary job of the five-foot long colon is to remove water from undigested material that is left, producing a concentrated waste material known as *feces*. This material passes through the rectum and is eliminated from the body.

Rich colonies of bacteria grow on the undigested material in the colon. These intestinal bacteria are helpful to the digestive process and some even produce useful vitamins.

**In the next lesson, we will examine the amazing liver.**

# LIFE PRINCIPLE



**"Let your food be your medicine and your medicine be your food."**

—Hippocrates (about 460 B.C.-377 B.C.)
Greek physician, Father of Medicine



The Human Body

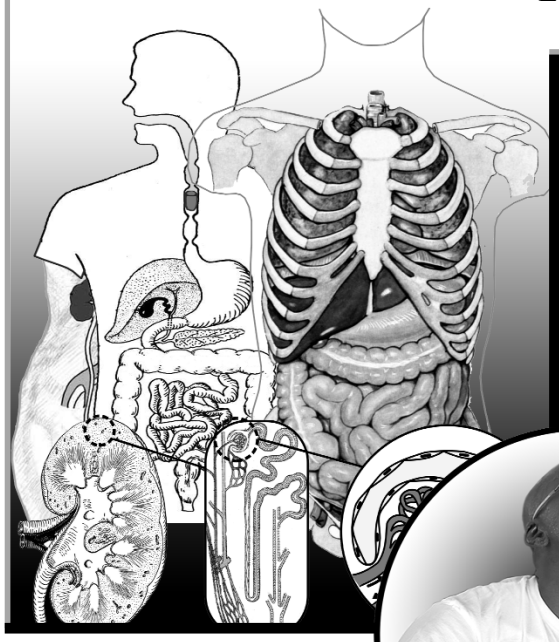
Lesson 8

# Chapter 2

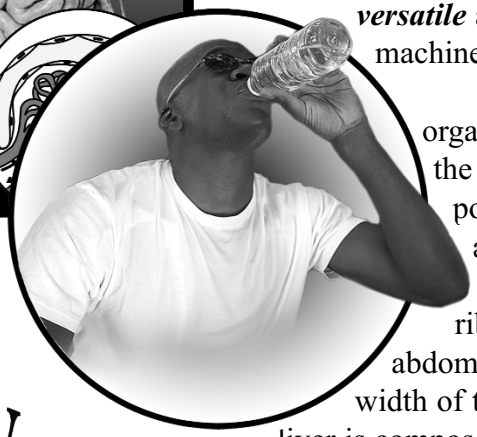
## THE HUMAN BODY: THE DIGESTIVE SYSTEM—THE AMAZING LIVER

**Section 2**

***Lessons 6-10***

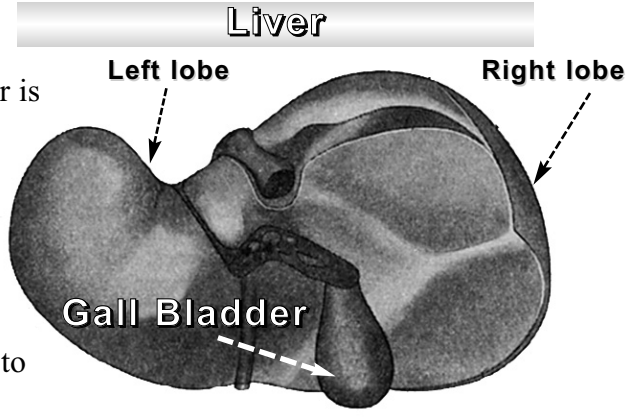


The liver is a remarkable and complex vital organ that performs the miracle of converting food into living energy and elements for sustaining life. The human system is a design marvel often compared to scientific machines: the steadfast pump of the heart, the remarkable bio-computer brain, and the electrical system of the nerves. The liver serves as the master chemical laboratory of the body and is more efficient, ***versatile*** and complex than any known machine.



The largest of the internal organs (about the size of a football), the liver weighs between 2.5 and 5 pounds, or about 2-3 percent of an adult's body weight. This organ is suspended behind the ribs on the upper right side of the abdomen and spans almost the entire width of the body over to the heart. The liver is composed of two separate lobes that operate independently of each other (in the event one side stops functioning). One unique feature of the liver is that it is capable of regenerating itself after a portion is removed. Amazingly, even after a loss of up to 75% of the organ due to injury or surgery, the remaining liver can grow back to normal size within about six months!

Inside the liver is a complex array of microscopic veins through which every cell of blood is filtered. Blood conditions are constantly monitored to




## VOCABULARY

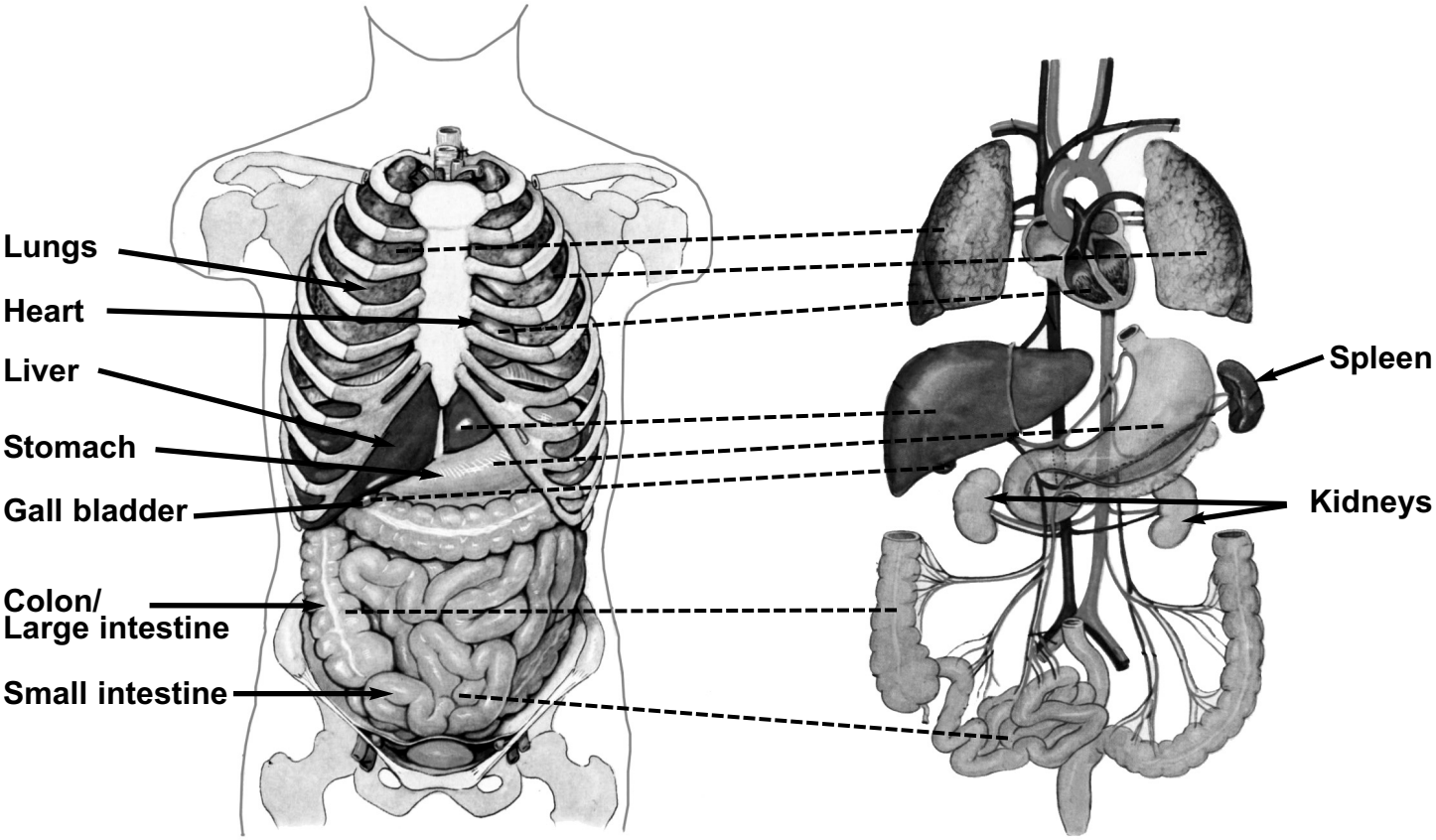
***Versatile***: possessing a wide variety of abilities

***Alkaline***: having a pH level higher than 7; the opposite of acidic

***Detoxified***: toxic, poisonous substances are neutralized

***Cirrhosis***: a liver disease marked by hardening of the liver tissue due to excessive formation of connective tissue; often a result of alcohol abuse or hepatitis C

## Location of Liver as Related to Other Organs




make sure that its chemistry meets strict standards. The liver is the body's recycling organ that is responsible for processing, converting, distributing and maintaining the body's energy supply. It converts the complex energy foods we eat—carbohydrates, fats and proteins—into simple glucose (blood sugar) or stores this fuel as glycogen. Fats are broken down and converted for distribution and storage.

The liver is responsible for breaking down proteins into amino acids, assembling proteins and making new amino acids for use throughout the body. It breaks down old blood cells and recycles the iron.

The liver also makes 13-32 ounces of *bile* daily. This yellowish-green ***alkaline*** liquid is stored in the gall bladder and secreted into the small intestine to help break down fats. Bile contains the pigments which give color to urine and feces. If the bile ducts become obstructed, bile pigments often cause the body to turn jaundice (yellow-tinted).

The list of liver functions includes the production of numerous hormones and proteins, which affect the way the body grows and heals. Many vitamins and other nutrients, like iron, are stored in the liver and released when needed. Poisons, such as alcohol and drugs, are ***detoxified*** in the liver.

This organ is vital for many reasons. No one has ever devised an artificial liver because it is so complex. Second only to the brain in complexity, the liver is the home of

### VOCABULARY

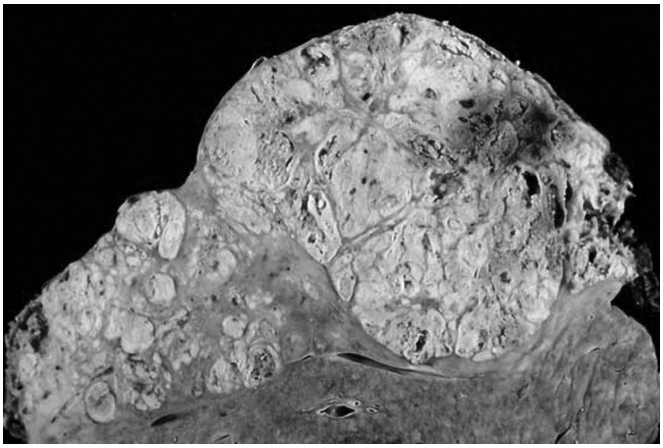
***Metabolize:*** pertains to a performance of metabolism—chemical changes taking place in basic living cells by which new material is assimilated and energy is provided

many of the mysteries of human life. As powerful as this organ is, it is also delicate and may fall prey to disease.

*Hepatitis* literally means "inflammation of the liver". This can be caused by contaminants such as alcohol, viruses, drugs and toxic blood exchange. One type of viral hepatitis, hepatitis A (also called *infectious hepatitis*), is usually transmitted through food and is more common where sanitation and hygiene are poor. The other type, hepatitis B, is a virus spread through exchange of blood (it is also known as *serum hepatitis*). Most commercial blood supplies are checked thoroughly for the hepatitis B virus. A more recent type of hepatitis (hepatitis C) appears to involve blood exchange or intravenous (I.V.) drug use and seems to be the most troublesome of all hepatitis infections. Often, no symptoms appear for 15 to 20 years; however, type C hepatitis can turn into ***cirrhosis*** or even liver cancer. Many people in the United States are receiving liver transplants for this type of hepatitis. Other patients have chosen natural ways to bring hepatitis C under control or to cure it.

Even moderate quantities of alcohol can damage the liver. Alcohol is a concentrated sugar which causes fat to be deposited in the liver. In effect, alcohol poisons the liver. Alcohol abuse can lead to alcoholic hepatitis or cirrhosis. As mentioned before, the liver is the one organ which has the amazing ability to regenerate itself. However, cirrhosis is a condition in which a liver damaged by disease, alcohol or drugs does not grow back 'as good as new.' In cirrhosis, the liver forms fibrous scar tissue and lumpy irregular nodules as it regenerates. In advanced cases, the liver becomes so badly scarred by cirrhosis that it can no longer do its work and the afflicted person dies of liver failure.

Cross section of cancerous, cirrhotic liver



Because of the liver's vital role, taking care of this organ is critical, beginning while you are still young. Eating a balanced diet and avoiding toxins such as drugs and alcohol are the best ways of assuring a healthy liver.

Scientists have identified well over 500 amazing functions of the human liver which fall into five categories. Some of these complex functions are:

**1. *Metabolizes* Nutrients:**
- —Converts fats, amino acids (proteins), carbohydrates into glucose
- —Converts glucose to glycogen for storage (and back again as body needs energy)

**2. Stores Nutrients:**
- —Stores and assimilates vitamins (A, B, D, E, K)
- —Stores minerals (iron, zinc, magnesium, manganese)
- —Stores extra blood for quick release

**3. Regulates Critical Substances in Blood**
- —Regulates glucose concentration
- —Regulates hormone levels
- —Regulates blood clotting factors
- —Helps to maintain blood pressure
- —Helps maintain electrolyte and water balance

**4. Manufactures, Replaces and Recycles Needed Substances**

—Recycles iron content of blood
—Creates bile
—Provides blood clotting factors
—Renews/replaces liver cells
—Constructs cholesterol and estrogen
—Constructs 50,000 systems of enzymes to govern metabolic activity throughout the body
—Reconstructs hormones
—Creates serum proteins which maintain fluid balance and act as carriers
—Creates immune substances, such as gamma globulin

**5. Modifies, Filters out, Detoxifies, Removes Harmful Substances**

—Removes products of tissue breakdown
—Helps modify/break down/remove harmful chemicals, drugs, alcohol
—Breaks down toxins created in the colon by bacteria (thus preventing death)

**In the next lesson, we will begin an examination of the excretory system.**

# LIFE PRINCIPLE



**"We are generally better persuaded by the reasons we discover ourselves than by those given to us by others."**

—Blaise Pascal, (1623-1662), French mathematician, physicist, and theologian



*The Human Body*

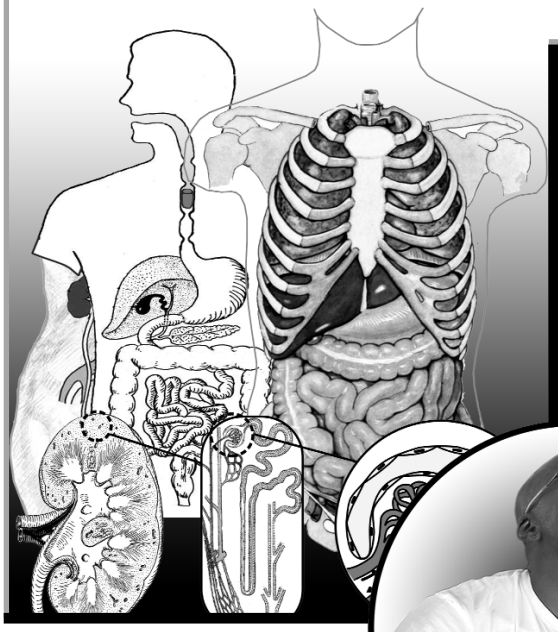
**Lesson 9**

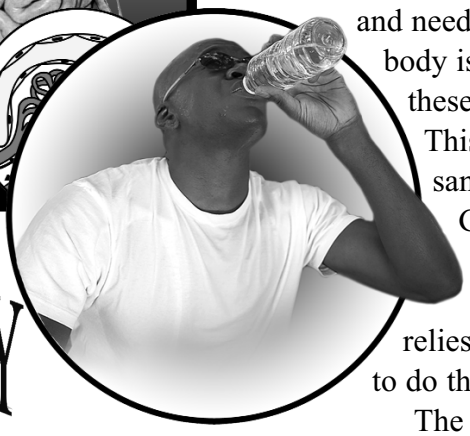
# *Chapter 2*

## THE HUMAN BODY: THE EXCRETORY SYSTEM—FUNCTION

## Section 2

***Lessons 6-10***





The chemistry of the human body is one of utmost complexity. As you have learned, an intricate system of checks and balances controls everything from your blood pressure to your body temperature. Nutrients are absorbed, stored, and carefully released just as they are needed. Everything in this living system produces chemical wastes which are byproducts of chemical reactions and are no longer needed. Some wastes are toxic and need to be excreted. Therefore, the body is constantly working to collect these wastes and eliminate them. This process might be likened to the sanitation department of a city. Garbage trucks come at pre-arranged times to haul trash to a waste site. The human body relies on a group of organs that work to do the same type of work.

The elimination of chemical wastes from the body is known as *excretion*. As you recall, the lungs act as an excretory organ as they remove carbon dioxide which is a chemical waste. The skin is also an excretory organ because it eliminates excess water and salt as sweat. The urinary system removes wastes from metabolic processes and regulates the content of our body's fluids.

### VOCABULARY

***Ureter***: vessel that carries urine to the urinary bladder

***Urinary bladder***: sac that stores urine before it is eliminated from the body

***Nephron***: Greek word for *kidney*; any of the numerous blood-filtering units of a kidney

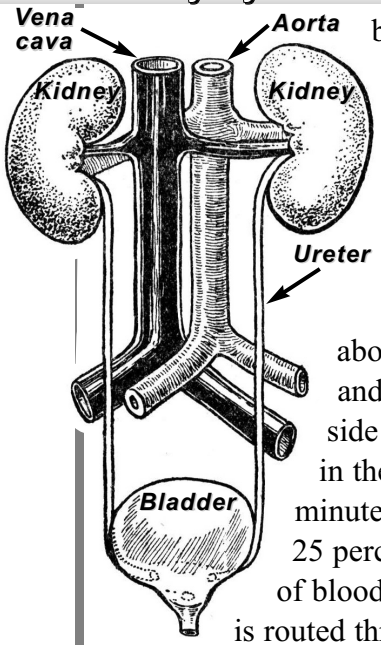
***Glomerulus***: ball of capillaries in a nephron that filters blood

***Bowman's capsule***: a cup-shaped receptacle that is the initial, expanded segment of the nephron where filtrates enter through the glomerulus

### THE KIDNEYS

In this lesson, we will focus our study on a pair of organs in the urinary system—the kidneys—whose main function is filtration and excretion of wastes. When the body uses the amino acids from proteins for food, it sometimes must remove amino groups which produce ammonia (NH3). Ammonia is a poisonous substance which is quickly converted by the body to urea. Urea is less toxic than ammonia but it still must be

## Excretory System




removed from the bloodstream. The removal of urea and the regulation of fluids in the bloodstream is the principle job of the kidneys.

The kidneys are each about the size of your fist and are located on either side of the spinal column in the lower back. Every minute of every day, nearly 25 percent of the 2,114 quarts of blood pumped by your heart is routed through the kidneys for cleaning. Blood flows into each kidney through a renal artery and leaves through a renal vein. A third vessel, called the ***ureter***, leaves each kidney carrying fluid to the ***urinary bladder***. Because of the presence of many blood vessels, the kidneys are colored a dark reddish-brown.

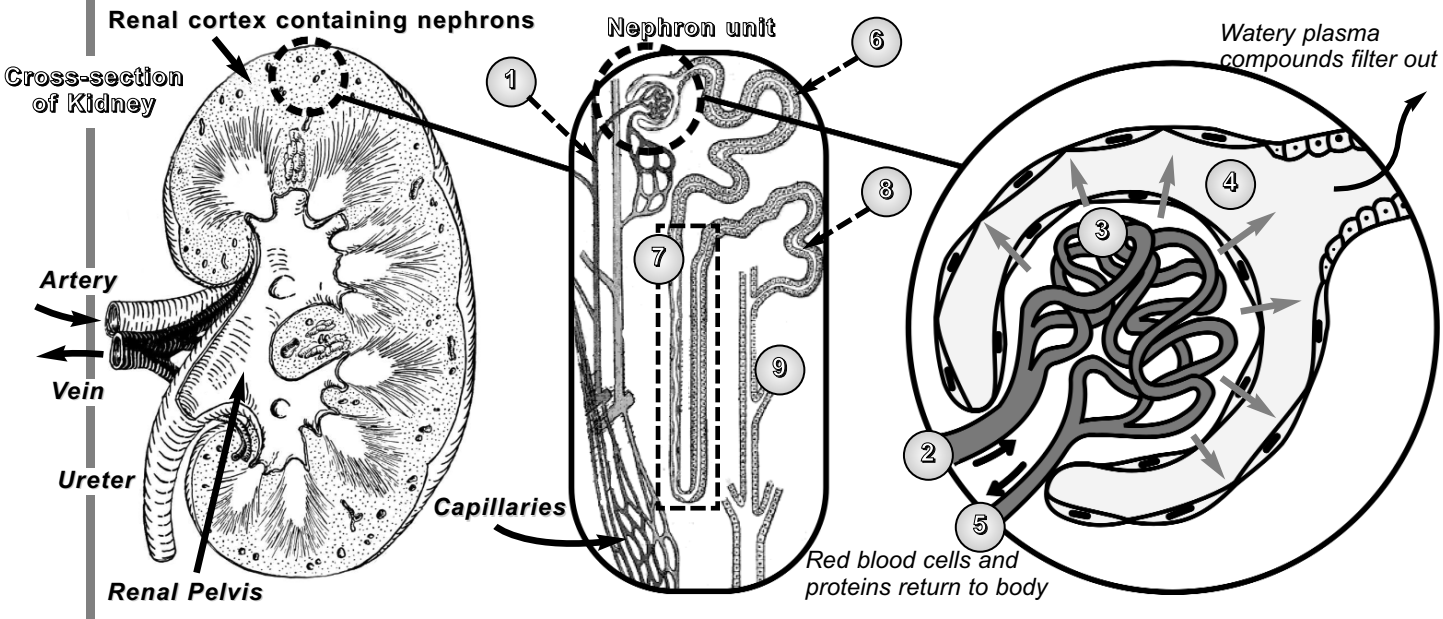
Within each kidney is a complex filtration system that removes urea, excess water and other wastes from the blood. As purified blood is returned to the body, these wastes are collected to form the fluid known as *urine*. Urine is stored in the bladder and then is eliminated from the body.

### The Nephrons

The renal cortex of each kidney contains about a million tiny functional units called ***nephrons***. Nephrons are part of the body's homeostatic mechanism. This efficient system, located in each kidney, is responsible for regulating the amount of water, salts, glucose, urea and other minerals in your body. This is where glucose eventually is absorbed into your body.

Blood enters each nephron through a single small artery (arteriole) and leaves through a small vein (venule). Each nephron also contains a collecting duct, which leads to the renal pelvis. Wastes and excess water

## The Human Kidney Filtering System




**Details of nephron unit:**

1. Renal artery
2. Vas afferens (blood plasma enters)
3. Glomerulus
4. Bowman's capsule
5. Vas efferens
6. Proximal tubule
7. Loop of Henle
8. Distal convoluted tube
9. Collecting duct

are removed from the bloodstream and are gathered in the collecting duct. Blood entering the nephron flows into a filtering station—a spherical network of thin-walled capillaries called a ***glomerulus***.

The glomerulus resembles a twisted mass of tiny tubes within a receptical called ***Bowman's capsule***. Each day, more than 48 gallons of ***blood plasma*** passes through the ***Vas afferens*** into the glomerulus. Both the glomerulus and capsule are semi-permeable, allowing water and soluble wastes to pass through their walls by osmosis.

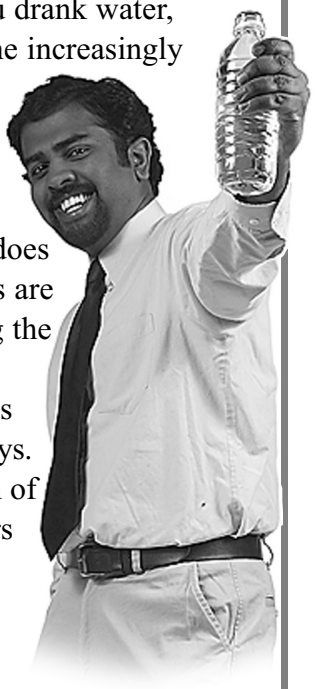
As the plasma moves through the *proximal tubule*, and the ***loop of Henle***, much of the material first removed from the blood is put back into the blood. This process is called *reabsorption*.

You might wonder why the nephron first "throws everything out", only to reabsorb most of the water and dissolved minerals split-seconds later. This could be compared to cleaning out a cluttered drawer by dumping out its contents, sorting them, and putting back only what you want. Although this procedure may seem inefficient at first, it actually is what makes the kidneys such effective filters. By first removing nearly everything from the bloodstream, the kidneys help to ensure that drugs, poisons and other dangerous compounds are filtered out and eliminated in the urine.

As the kidneys reabsorb usable material into the bloodstream, they draw back nearly 99 percent of the fluid that had first been filtered out. The remaining fluid—the diluted urine—is further concentrated as it moves through the *distal tubule* and the *collecting duct* toward the urinary bladder and ureter. Depending on the demands of the body, the nephron can produce urine appropriate for the situation. If the body is becoming dehydrated, the urine will be very concentrated and a bright to dark yellow color, which indicates that the body is conserving water. If the body is well hydrated, the urine will be dilute and pale yellow to clear in color, indicating the elimination of more water.

## Control of Water Balance

The water you drink is quickly absorbed by the digestive system and passed into the bloodstream. If that were all that happened every time you drank water, your blood would become increasingly diluted. Osmosis would cause water to flow into the body tissues, and many of them would swell. Fortunately, this does not happen. The kidneys are responsible for removing the excess water.



The brain controls the function of the kidneys. The hypothalamus region of the brain closely monitors the water content of the blood. When the water concentration is too low,

### VOCABULARY

***Blood plasma***: blood fluid containing red blood cells, water, salts, sugars and nutrients
***Vans afferens***: Latin for *entry vessel* or "bringing in"
***Loop of Henle***: named for German anatomist F. J. Henle; region of the nephron of the kidney where concentrated urine is produced
***Vans efferens***: Latin for *exit* or "take away vessel"

the hypothalamus signals the pituitary gland to release an Anti-Diuretic Hormone (ADH). ADH causes its target cells in the tubules of the kidneys to reabsorb more water. This action returns more water to the bloodstream to conserve body water and, thereby, produces concentrated urine. If the water content of the blood rises, ADH is not released and the tubules reabsorb much less water. Diluted urine is produced and the body quickly eliminates the excess water.

Urine that is dark yellow in color indicates a very concentrated waste. This, in turn, indicates that the person is not drinking enough water. If this condition continues long-term, the person will risk dehydration. Doctors generally recommend that those who have reached physical adulthood drink 6-8 eight-ounce glasses of water a day. However, people vary greatly in weight, so that amount may be too much for some persons or too little for others. Some health counselors recommend drinking water that equals half of your body weight in ounces. For example, if you weighed 100 pounds, you would drink 50 ounces of water (about 6 cups) daily.

**In the next lesson, we will study some of the other amazing features of the kidneys.**

# LIFE PRINCIPLE



**"Water is the only drink for a wise man."**

—Henry David Thoreau (1817-1862)
American essayist and poet



The Human Body

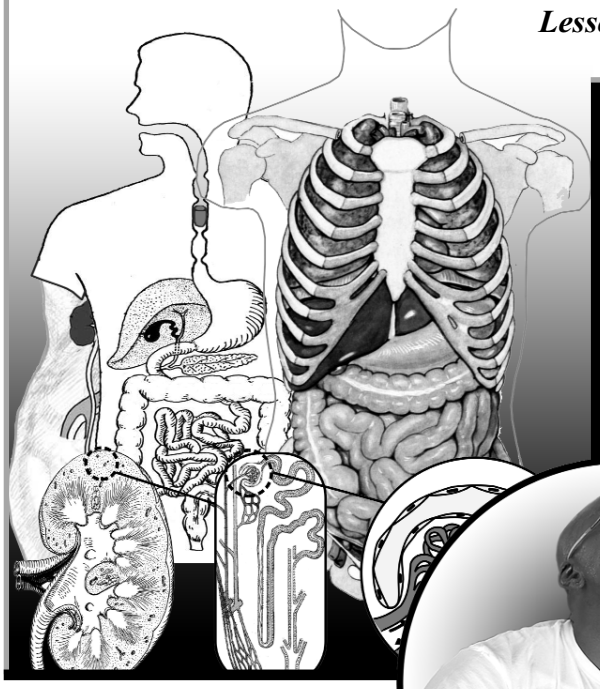
**Lesson 10**

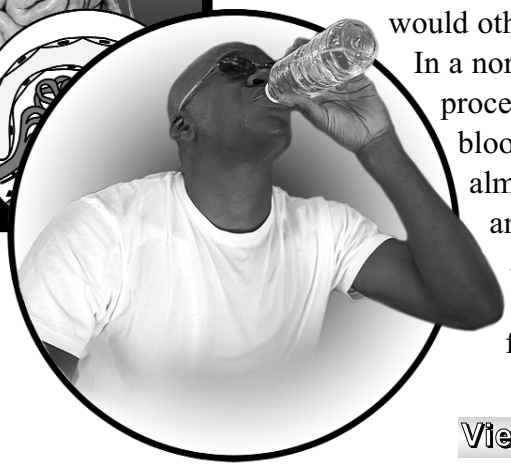
# *Chapter 2*

## THE HUMAN BODY: THE EXCRETORY SYSTEM—THE AMAZING KIDNEYS

**Section 2**

***Lessons 6-10***

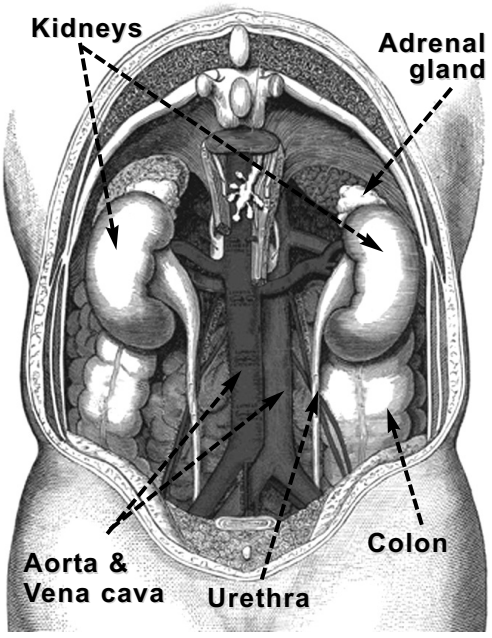




As you learned in the previous lesson, the nephron is a multi-tasking system that performs the functions of filtration, reabsorption and secretion simultaneously. All of the blood in the human body is filtered through the kidneys about 20 times each hour. Your blood passes through 60,000 miles of vessels and picks up waste from the cells. The kidneys use water to remove the toxins that would otherwise poison the blood. In a normal adult, the kidneys process about 48 gallons of blood a day, which amounts to almost 1.5 million gallons in an 80-year lifetime! This is an extraordinary amount of liquid for any machine to filter.

The urinary tract is generally well-protected from infection. However, when infections of the urinary tract do occur, women are affected far more often because the female ***urethra*** is about 1.5 inches long compared to about 8 inches in the male. Groups of muscles near the urethra keep the system shut most of the time and help prevent infection. The outward and downward flow of urine also helps by flushing out microorganisms

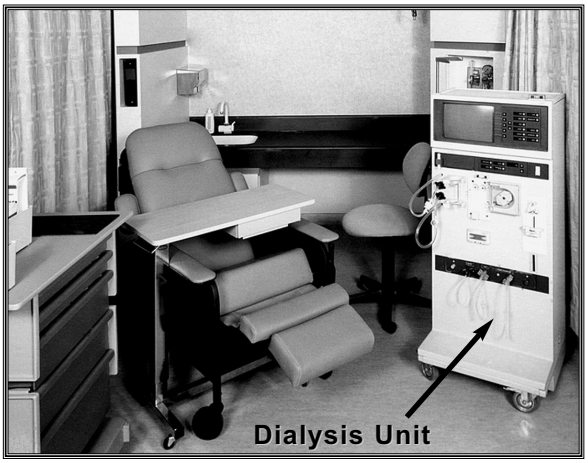
View of Kidneys from behind



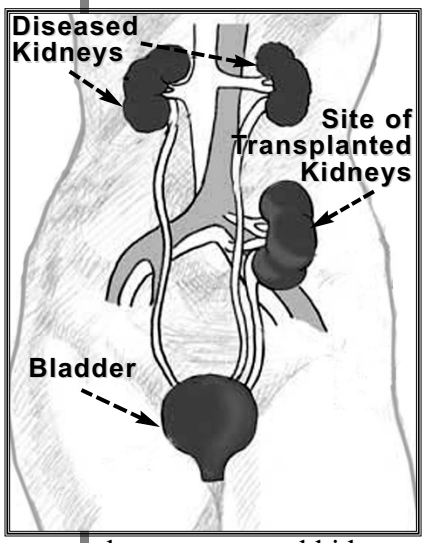

## VOCABULARY

***Urethra***: the tube that releases urine from the body near the vagina in females or through the penis in males; also serves in males as the exit tube for the reproductive system

before they have a chance to multiply and cause infection.




Normal urine, although a waste product, contains anti-microbial substances such as organic acids and small quantities of antibodies. (This waste product has been strangely recycled as a mouthwash, toothpaste and general cleaning agent down through history, from the apex of the Roman Empire well into the 1700s. Although not knowledgeable of any antimicrobial properties of urine, Romans imported quantities of it for personal hygiene use. Portugese urine was especially prized because it was deemed to be stronger. Ammonia compounds found in urine have served as great cleaning agents. Such compounds are still used in various modern toothpastes; however, they are produced in *laboratories* instead of *lavatories*.)




## Infections and Diseases

During urinary tract infections, larger quantities of specific antibodies can be found in the urine. Some kidney and urinary tract infections are difficult to cure and can, ultimately, destroy a normal kidney.

Fortunately, humans have two kidneys. If one is lost, life proceeds almost normally. The remaining kidney enlarges to assume the function of both organs. However, if function in both kidneys is lost, a person will have to experience dialysis treatment or a kidney transplant to survive. Dialysis is a process of separating molecules of different sizes, using a semi-permeable membrane. Kidney dialysis units permit patients to obtain their dialysis treatments two or three times a week, as needed. From a vein in the arm, blood flows into the unit where it passes through a semi-permeable membrane that removes wastes. A second filter removes air bubbles before the machine pumps the cleansed blood back into the body.

The dialysis machine, made by bioengineers, can help a person overcome kidney disease temporarily—by offering substitute kidney action for several months. Newer experimental technology may help some patients for periods up to four years. Eventually, the patients will need to receive a kidney transplant. Few people would want to be on dialysis for the rest of their lives. Obviously, the best policy is to take care of your kidneys while you are young. Normal, healthy kidneys perform much more efficiently than man-made machines. One of the best acts of prevention is to drink at least six to eight glasses of clean water daily and avoid the intake of alcohol or drugs.

Among major diseases, kidney problems rank fifth in the United States, killing over more than 100,000 Americans each year. One of the most common kidney problems is kidney "stones" (or "gravel" as the oldtimers described them). Such crystals

are largely composed of uric or oxalic acid and calcium salts that form in the urine. Uric acid is a component of meat (especially red meat) that can, over time, produce crystals in places like joints and kidneys when too much meat is consumed. Calcium is needed by the body, in balance with other minerals such as magnesium, for strong bones and teeth plus other important functions. However, out of balance, calcium can contribute to unwanted deposits in the kidneys and elsewhere in the body. This is why magnesium (which acts like an internal policeman, directing calcium traffic to proper locations), is sometimes prescribed to help prevent or remediate calcium-based kidney stones. Oxalic acid occurs abundantly in certain plant foods such as rhubarb, spinach and other "greens", and to a lesser extent in some other fruits and vegetables (all of which also house many beneficial nutrients). Persons prone to oxalic acid stones may benefit from avoiding an excess of these foods.



Child suffering from *edema*

Kidney stones can be extremely painful as they pass through the kidney and ureter, and if stones block the flow of urine, infection may result. Kidney stones can be disintegrated with ultrasound or removed surgically. Some promising research indicates that kidney stones may be able to be dissolved by oral medication or other supplementation. Certain American Indian tribes used herbs such as hydrangea root to combat "gravel" in the urine. Incorporating some lemon juice each day is sometimes prescribed to help prevent or dissolve stones.

*Nephritis*, which is an infection of the nephrons, is a more serious condition. Symptoms include high blood pressure, weakness, fatigue and edema (water retention resulting in swelling of hands and feet). Repeated attacks of nephritis may lead to permanent kidney damage, as well as kidney failure, in which the kidneys stop functioning altogether.

**In the next lesson, we will begin a study of the immune system.**

***Career Bound?***

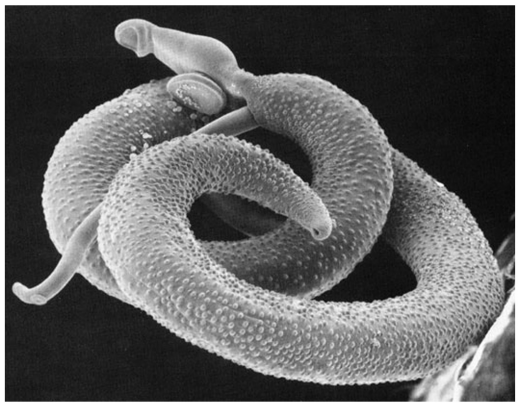
Dialysis Technicians, also called *hemodialysis* or *renal dialysis* technicians, operate kidney dialysis machines which filter normal waste products and excess fluids from the blood of patients whose kidneys can no longer perform that function. Dialysis Technicians, who perform their duties under the supervision of physicians or registered nurses, have clinical and technical skills and can be responsible for direct patient care, as well as dialysis equipment maintenance and repair.



# LIFE PRINCIPLE

**"A huge chip on your shoulder causes you to lose your balance."**

—John Mason, author and motivational speaker in *Conquering an Enemy called Average*





The Human Body

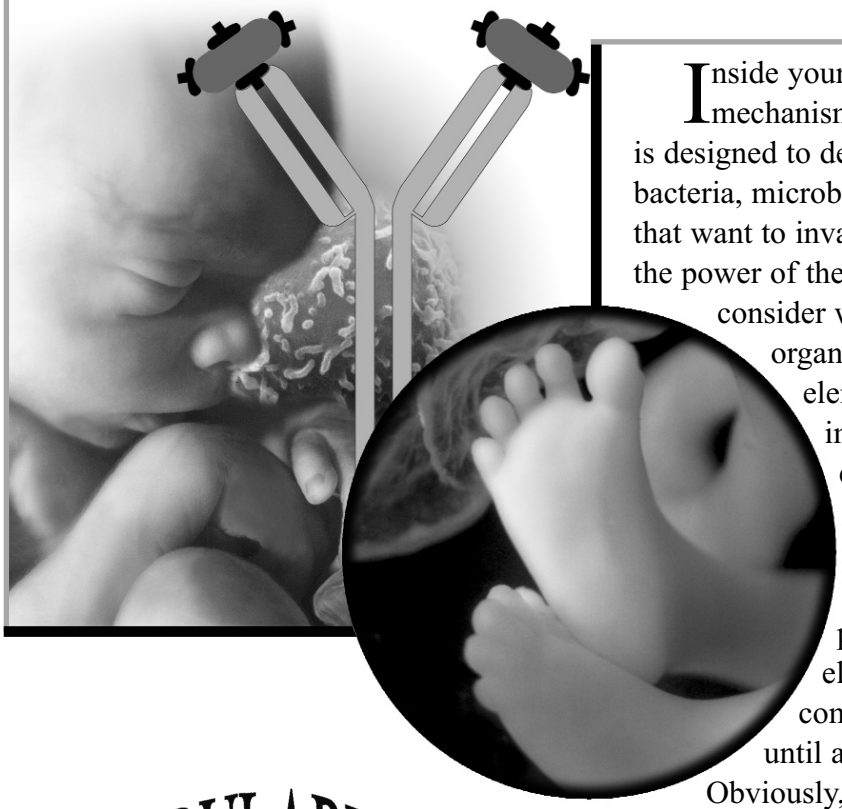
Lesson 11

# Chapter 2

## THE HUMAN BODY: THE IMMUNE SYSTEM—INTRODUCTION

### Section 3

*Lessons 11-15*



Inside your body is an amazing protection mechanism called the immune system. It is designed to defend you against millions of bacteria, microbes, viruses, toxins and parasites that want to invade your body. To understand the power of the human immune system, consider what happens to a living organism after it dies, if left to the elements. Upon death, the immune system (along with everything else) ceases to operate. In a matter of hours, the body is invaded by bacteria, microbes and parasites. Only a few weeks elapse before tiny organisms completely dismantle the flesh, until all that remains is the skeleton. Obviously, your immune system is doing something amazing to keep all of that dismantling from happening while you are alive!

The immune system is complex and intricate, working around the clock in thousands of different ways, but it does its work largely unnoticed. One thing that causes you to notice your immune system is its failure to function. For example, when you get a cut, a myriad of bacteria and viruses enter your body through the break in the skin. When you get a splinter, you also have the sliver of wood as a foreign object inside your body. Your immune system responds and eliminates the invaders while the skin heals itself and seals the puncture. Sometimes, if the immune system is weak, or the wound is not kept clean, the cut becomes infected. It gets inflamed and will often fill with ***pus***. ***Inflammation*** and pus are both side effects of the immune system, heroically doing its job.

## VOCABULARY

***Pus***: a thick, yellowish-white substance formed at site of cellular injury; contains leukocytes, microorganisms and tissue debris

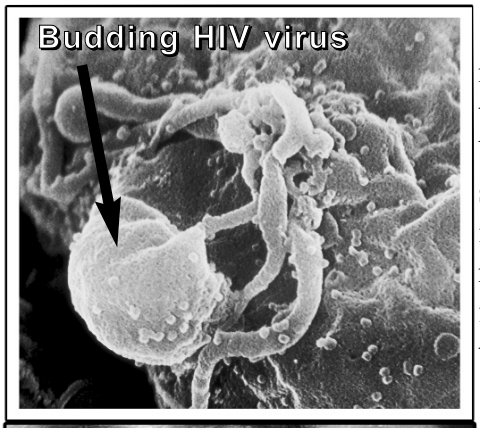
***Inflammation***: an immune system response at the site of cellular injury; marked by redness, heat and pain

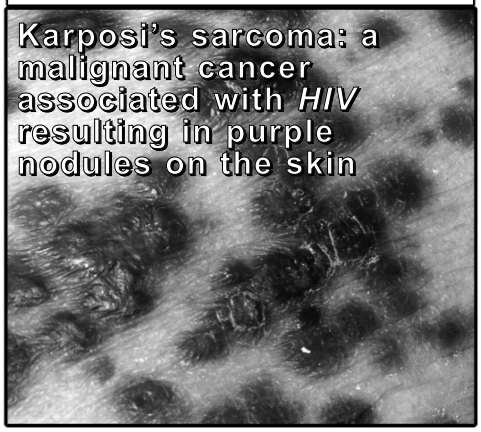
***Hamper***: to restrict, restrain, disrupt, impede

***Pathogen***: disease causing organism

## Common Diseases and Pathogens

| Pathogen Types | Resulting Disease | Organisms causing disease | How diseases spread |
|---|---|---|---|
| **Bacteria** | Cholera | Vibrio cholerae | Drinking contaminated water |
| | Diphtheria | Corynebacterium diptheriae | Drinking contaminated milk; contact with infected carrier |
| | Lyme Disease | Borrelia burgdorferi | Being bitten by infected tick |
| | Meningitis | Neisseria meningitis | Being directly exposed to living bacterium |
| | Rocky Mountain spotted fever | Rickettsia rickettsil | Being bitten by infected tick |
| | Tetanus | Clostridium tetani | Dirty, unsterilized puncture wound or cut |
| | Tuberculosis | Mycobacterium tuberculosis | Contacting droplets within the air; consuming contaminated milk products |
| **Fungal** | Tinea Pedis (athlete's foot) | Trichophyton rubrum and T.mentagrophytes | Walking barefoot in moist environments (showers); sharing footwear with infected persons |
| | Tinea (ringworm) | Dermatophytosis | Sharing headgear and clothing with infected persons; handling infected animals |
| **Protozoans** | African trypanosomiasis (african sleeping sickness) | Trypanosoma | Transmitted by infected *tsetse fly* |
| | Malaria | Plasmodium | Transmitted by female *Anopheles mosquitoes* |
| **Viruses** | Acquired Immunodeficiency Syndrome (AIDS) | Human Immunodeficiency Virus (HIV) | Sexual contact; exposure to infected body fluids; mother to child during pregnancy or breastfeeding |
| | Varicella zoster (chickenpox) | Varicella-zoster virus | Transmitted by air; direct contact with infection |
| | Acute viral nasopharyngitis (common cold) | Rhinovirus | Transmitted by air; direct contact with infected person |
| | Influenza | Influenzavirus A, Influenzavirus B, and Influenzavirus C | Transmitted by air; contact with body fluids of infected person and contaminated surfaces |
| | Measles or Rubella | Morbillivirus | Direct contact with infected body fluids or through air transmission |
| | Smallpox | Variola major and Variola minor | Direct contact with body fluids or contaminated objects |
| **Worms** | Beef tapeworm | Taenia saginata | Eating contaminated meat |
| | Schistosomiasis or bilharzia | Schistosoma mansoni | Freshwater streams and rice paddies |
| | Trichinosis | Trichinae | Eating undercooked pork |

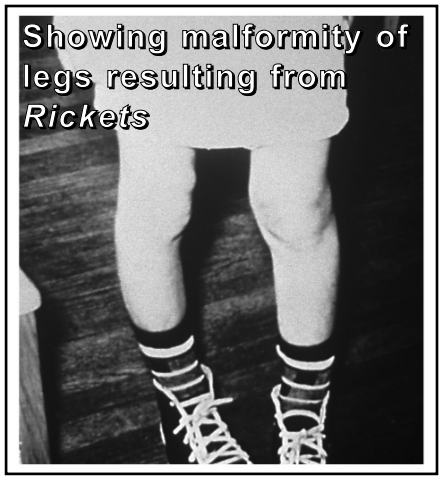



Each day you *inhale* thousands of germs (bacteria and viruses) that are floating in the air. Your immune system deals with all of them without a problem. Occasionally, some germs get past the immune system and you catch a cold, get the flu, or some other contagious disease or virus. A cold, or flu, is a visible sign that your immune system failed to stop the germs. The fact that you get over such infections is a visible sign that your immune system was able to eliminate the invaders after learning about them. If your immune system did nothing, you would never recover from a cold or any other disease.

Each day, you also *ingest* thousands of germs. Thankfully, most of these die either in your saliva or stomach acid. Occasionally, however, some get through and cause food poisoning. Normally, two very visible effects of this breach of the immune system occur: vomiting and diarrhea.

Some human ailments are caused by the immune system working in unexpected or incorrect ways that cause problems. For example, some people have allergies. Allergies are really just the immune system overreacting to certain stimuli that other people do not react to at all. In many different diseases, the cause is actually an immune system error.




The immune system may prevent us from doing things that otherwise would be beneficial. For example, the success of an organ transplant is often ***hampered*** because the recipient's immune system frequently rejects the transplanted organ.

## Disease

A disease is any biological change that disrupts normal bodily functions. Disruption can happen in a variety of ways. You might experience a vitamin or mineral deficiency. For example, if you do not intake sufficient vitamin D during childhood through sunshine or supplementation, your body will be unable to metabolize calcium properly and risks contracting a disease known as *rickets*. People with rickets have weak bones (they break easily) and deformities occur because the bones do not grow properly. If you do not consume enough vitamin C through fruits and vegetables or supplementation, you risk *scurvy*, which causes swollen and bleeding gums, swollen joints, easy bruising and ultimately death.

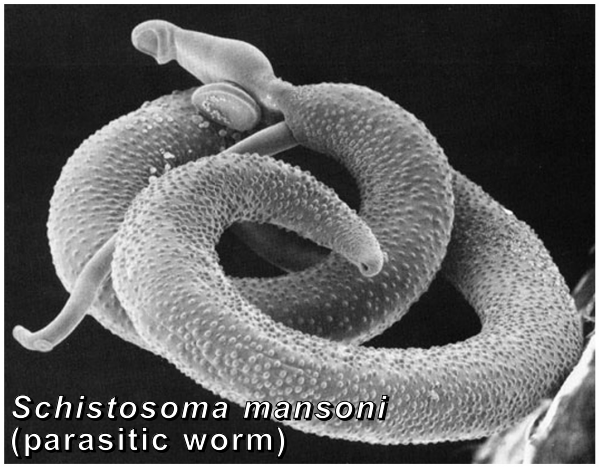
Disease might also be caused by organ degradation. In some cases, an organ is damaged or weakened. As you will recall, arteriosclerosis is a disease caused by obstructions in the blood vessels leading to the heart muscle, so that the heart does not get enough blood. Cirrhosis of the liver results from damage to liver

cells, often caused by over-consumption of alcohol.

Genetic diseases are caused by coding errors in the DNA. Coding errors cause too much or too little of certain proteins to be made, causing problems at the cellular level. For example, *albinism* is caused by a lack of an enzyme called *tyrosinase*. That missing enzyme means that the body cannot manufacture melanin, the natural pigment that causes hair color, eye and skin color. Because of the lack of melanin, people with this genetic problem have eyes with pink irises and deep red pupils, very white skin and hair, and are therefore extremely sensitive to the ultraviolet (UV) rays in sunlight.

Cancer is another form of disease which occurs when cells change in a way that causes them to reproduce uncontrollably. For example, when cells, called *melanocytes*, in the skin are damaged by ultraviolet radiation in sunlight, the characteristics of the cells change into a cancerous form. The visible cancer that appears as a dark-pigmented tumor, or lumpy mole, on the skin is called a *melanoma*.

Diseases are also produced by organisms, including bacteria, fungi, protozoans, worms and viruses, and are called ***pathogens***. Diseases caused by pathogens are generally known as *infectious diseases*.


*Schistosoma mansoni* (parasitic worm)

Many of the microorganisms that fill the world also live around and inside the human body. The large intestine harbors dense colonies of bacteria. Bacteria and yeast are found in the mouth, throat and excretory system. Fortunately, most of these organisms are harmless and a few of them are actually beneficial.

Pathogens, however, are harmful. Some pathogens actually destroy cells as they grow. Others grow directly inside cells of the human body by eating those cells' food and, thereby, ultimately destroying the cells. Other pathogens produce toxins, or poisons, that disrupt bodily functions and produce illness. Many pathogens, especially parasitic worms, produce sickness when they block the flow of blood, remove nutrients from the digestive system, and disrupt other bodily functions.

Viral and bacterial infections are by far the most common source of illness, causing diseases such as colds, influenza, measles, mumps, malaria and AIDS. The job of your immune system is to protect your body from these infections. The immune system protects you in three different ways:

1. It creates a barrier that discourages pathogens from entering your body.
2. When pathogens do get into the body, the immune system tries to detect and eliminate them before they can establish a "home" and reproduce.
3. If the pathogens are able to reproduce and start causing health problems, your immune system works overtime to eliminate the pathogens.

The most obvious part of the immune system is what you can see: your skin. This is an important part of the first line of defense of your immune system. Skin acts as a primary boundary between germs and your body. Skin is tough and generally

impermeable to bacteria and viruses. The skin also secretes antibacterial substances. These substances explain why you do not wake up each morning with a layer of mold growing on your skin! Most bacteria and spores that land on the skin die quickly. The skin is considered a *nonspecific* defense because it is not directed against any one pathogen. Instead, a nonspecific defense guards against all infections, regardless of their cause.

When pathogens do enter into the body through a cut or other injury they grow quickly, spreading and releasing toxins into the tissues. When this happens, a second nonspecific defense is activated. This is called the *inflammatory response* because it can cause the skin to turn very red. Blood vessels near the wound expand, and white blood cells leak from the vessels to invade the infected tissues. Many of these white cells, called *phagocytes*, engulf and destroy bacteria. The infected tissue may become swollen and painful as the battle rages between the pathogens and white blood cells.

Your nose, mouth and eyes are also nonspecific defenses and are obvious entry points for germs. Tears and mucus contain the enzyme *lysozyme* that breaks down the cell walls of many bacteria. Saliva is also anti-bacterial. Since the nasal passage and lungs are coated in mucus, many germs not killed immediately are trapped in the mucus and soon swallowed. Any bacteria or virus attempting to gain entry to your body must first fight past these defenses.

Once inside the body, an amazing system of defense is waiting for the pathogen. You will read about this in the next lesson.

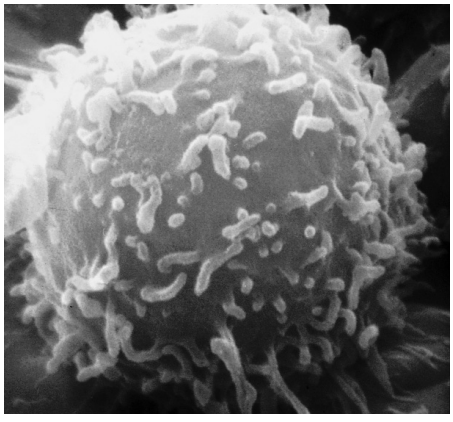
**In the next lesson, we will examine the different components of the immune system within the body.**

# Life Principle



**"Look to your health; and if you have it, praise God and value it next to conscience; for health is the second blessing that we mortals are capable of, a blessing money can't buy."**

—Izaak Walton (1593-1683)
English biographer





The Human Body

Lesson 12

# Chapter 2

## THE HUMAN BODY: THE IMMUNE SYSTEM—FUNCTION

**Section 3**

***Lessons 11-15***



When a serious infection causes pathogens to spread, the body responds in two ways. First, the immune system releases chemicals that increase the body's temperature. You have probably experienced this elevated body temperature, commonly called a *fever*. Second, the immune system produces millions of white blood cells to fight the infection. An increased number of white blood cells in the blood is a sign that the body is dealing with a serious infection.

The white blood cells are considered the most important part of your immune system. Many different classifications of white blood cells are working inside your body at this very moment. All white blood cells are known officially as *leukocytes*. White blood cells are not like other body cells. White cells act like independent, living, single-cell organisms able to move and capture things on their own. White blood cells behave very much like amoeba in their movements and are able to engulf other cells and bacteria. Many white blood cells cannot divide and reproduce on their own. Instead, they are produced in the bone marrow.

The immune system is also capable of powerful specific defenses that produce ***immunity*** against particular diseases. Immunity is the ability of the body to resist a specific pathogen. Since ancient times, physicians have observed that individuals who recover from certain diseases, such as mumps and measles, never again become sick with the same disease. This means that most people who recover from the mumps or measles are permanently immune from these diseases.

## VOCABULARY

***Immunity***: ability of the body to resist a specific pathogen

***Antibodies***: large proteins that are the basic functional units of a specific immune response

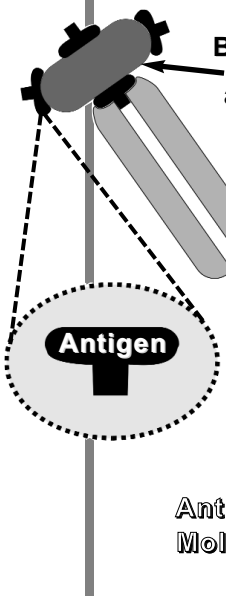
***Lymphocyte***: white blood cell that produces antibodies to assist the immune system

***B cell***: lymphocyte that matures in bone marrow and produces antibodies

***T cell***: white blood cell that matures in the thymus gland and regulates other cells of the immune system

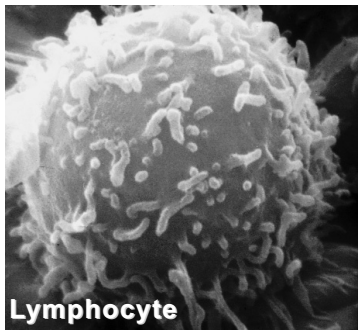
## ANTIBODY IMMUNITY

Exposure to certain diseases produces permanent immunity because it stimulates cells in the immune system to make proteins called ***antibodies***. Molecules that stimulate the production of antibodies are known as *antigens*. An antigen is any substance such as a bacteria, virus or toxin that triggers the specific defense of the immune system.




Antibodies are produced by white blood cells. Each is a Y-shaped protein that responds to a specific antigen. Further more, each antibody has a special section (at tips of the two branches of the Y) that is sensitive to a specific antigen and binds to it. When an antibody binds to a toxin, it is called an *antitoxin.* If the toxin comes from some form of venom, it is called an *antivenom*. The binding generally disables the chemical action of the toxin. When an antibody binds to the outer coat of a virus particle or the cell wall of a bacterium, it can stop their movement through cell walls. In addition, a large number of antibodies can bind to an invader and signal to the complement proteins that the invader needs to be removed. Complement proteins are activated by, and work with, the antibodies. These proteins cause *lysing* (bursting) of cells and signal to phagocytes that a cell needs to be removed.

The immune system also includes a special class of white blood cells called ***lymphocytes***. One group of lymphocytes, the B-lymphocytes, or ***B cells***, produce custom-made antibodies. As B cells develop, the antibody genes within each of them rearrange themselves in slightly different ways. When their development is complete, the immune system contains literally millions of B cells, each capable of producing a slightly different antibody.


Lymphocyte

When a pathogen enters the body, molecules on the invader's surface are recognized by the body as antigens to stimulate the body's immune system. This process is aided and regulated by ***T cells***. In a few days B cells, whose antibodies match the shape of the antigen, will start to multiply rapidly. This produces a large number of specialized B cells called *plasma cells* that release antibodies into the bloodstream to fight the infection. Millions of plasma cells may be produced from a handful of B cells stimulated by antigens, although many days may be needed for enough plasma cells to form and

### VOCABULARY

***Vaccine***: weakened or mild form of a pathogen that produces immunity to disease when injected into the body

***Killer T cell***: type of lymphocyte in the immune system that attacks and destroys a virus-infected cell

***Cell-mediated immunity***: action of immune system using cells rather than an antigen to attack a pathogen

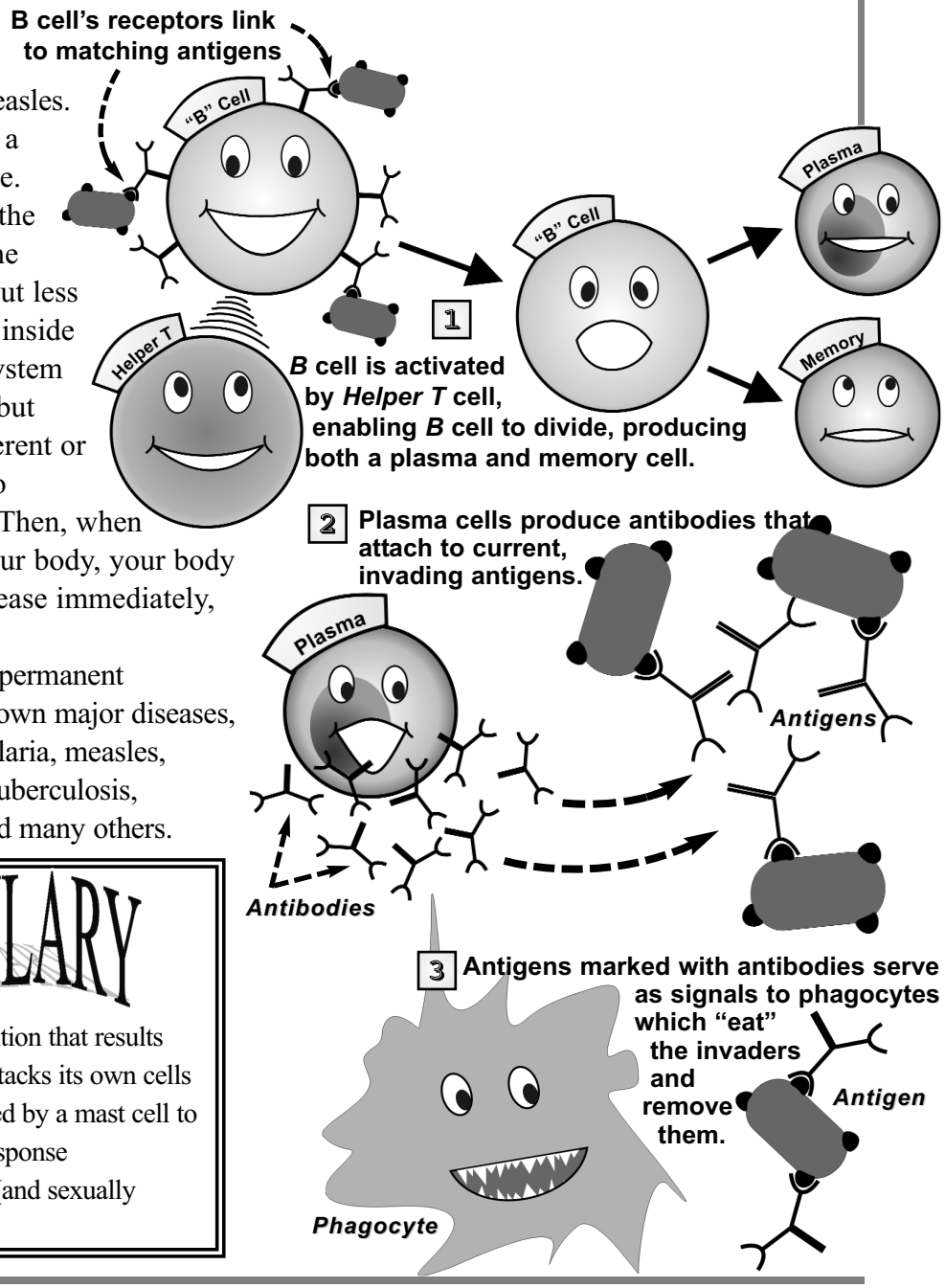
***Helper T cell***: type of lymphocyte in the immune system that identifies a specific pathogen in the body

help to overcome an infection. Plasma cells have another important function—to provide permanent immunity to certain diseases. For example, when a person contracts measles, antigens on the surface of the virus stimulate the production of millions of plasma cells to fight the infection. As a result, if the person survives the infection, his or her immune system retains those plasma cells and is always ready to respond with a massive supply of the measles antibody whenever the person is exposed to the measles.

A ***vaccine*** contains a weakened form of a disease. Either it is a dead form of the virus or bacteria causing the disease, or it is a similar, but less virulent, live strain. Once inside your body your immune system mounts the same defense, but because the disease is different or weaker you have few or no symptoms of the disease. Then, when the real disease invades your body, your body is able to eliminate the disease immediately, making you immune to it.

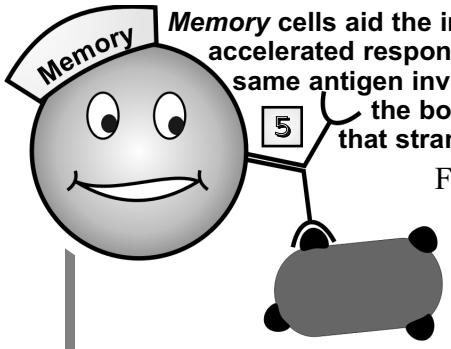
Vaccines providing permanent immunity exist for most known major diseases, both viral and bacterial: malaria, measles, mumps, whooping cough, tuberculosis, smallpox, polio, typhoid and many others.

However, many diseases cannot be prevented by vaccines. The common cold and influenza are two good examples. These diseases either mutate so quickly, or have so many different strains, that doctors cannot isolate and inject all of them into your body. Each time you get the flu, for example, you are probably getting a different strain of the same disease. The SARS epidemic of 2003 illustrates the elusive nature of influenza viruses.




## VOCABULARY

***Autoimmune disease***: condition that results when the immune system attacks its own cells
***Histamine***: chemical released by a mast cell to produce an inflammatory response
***Monogamy***: being married (and sexually faithful) to one person




***Memory* cells aid the immune system's accelerated response should the same antigen invade again, giving the body immunity to that strand of bacteria.**

Flu vaccinations are encouraged by many people in the medical establishment; however, many other doctors point to statistics indicating that a high percentage of those who receive the vaccine still succumb to a rough bout with the disease.

As more vaccines are available, more doctors seek to administer the serum in multiple doses at the same time as a matter of expediency. However, new evidence points to potential health hazards from this practice due to the toxic mercury, fluoride and/or aluminum content of vaccines used as preservatives. For example, the sharp rise in cases of autism has been linked to the administration of "batch doses" of vaccines to young children whose immune systems were unable to cope with the toxic load.

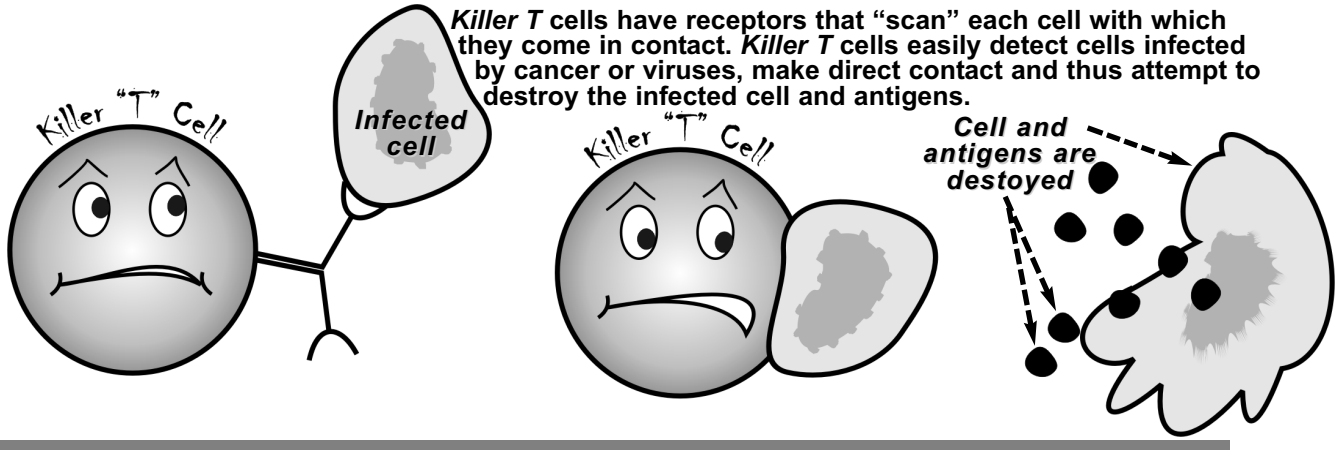
## Cell-Mediated Immunity

Antibodies alone are not enough to protect the body against some pathogens. In these cases, the immune system has a powerful weapon called the ***killer T cell***. Killer T cells make direct contact with antigen-bearing cells, disrupting their cell membranes and destroying them. This process is known as ***cell-mediated immunity***. The actions of killer T cells are very important in fighting certain types of infections. Killer T cells attack and destroy virus-infected cells, and they are important in fighting protozoans and multicellular parasites.

Unfortunately, killer T cells are also responsible for the rejection of tissue transplants. The cells of your body have a special set of protein markers on their surfaces that enable the immune system to recognize them as your own. If tissues from another person are transplanted into the body, the immune system checks the markers, recognizes them as foreign and attacks them. To prevent tissue rejection, physicians search for an organ donor whose cell markers are nearly identical to those of the recipient. Drugs are also used to suppress the cell-mediated immune response system.

In addition to killer T cells, ***Helper T cells*** are the first cells to identify the specific pathogen in the body. The helper T cells then send a message to the B cells to produce antibodies for that particular pathogen.

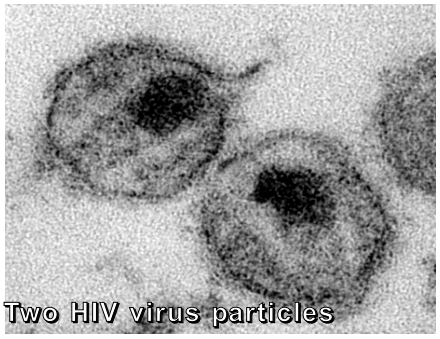
Another kind of T cell is a *suppressor T cell*. After an infection has been fought successfully, suppressor T cells shut off the immune response in both B cells and killer T cells.




***Killer T* cells have receptors that "scan" each cell with which they come in contact. *Killer T* cells easily detect cells infected by cancer or viruses, make direct contact and thus attempt to destroy the infected cell and antigens.**

## Immune Disorders

Although the immune system protects the body against many pathogens, sometimes disorders occur. ***Autoimmune diseases*** occur when a person's immune system attacks his/her own body in the same way it would normally attack a germ. *Juvenile-onset diabetes* is caused by the immune system attacking and eliminating the cells in the pancreas that produce insulin. *Rheumatoid arthritis* is caused by the immune system attacking tissues inside the joints. *Systemic Lupus Erythematosus* (SLE) and *Multiple Sclerosis* (MS) are among an increasing number of diseases being classified as autoimmune diseases.


Two HIV virus particles

Allergies are another form of immune system disorder. Allergic reactions occur when the immune system strongly reacts to an antigen in the environment. The antigen might be a certain food, or a certain type of pollen, or a certain type of animal fur. For example, a person allergic to a specific pollen will experience a runny nose and watery eyes. This reaction is caused primarily by *mast cells* in the nasal passages releasing chemicals called ***histamines***. Histamine has the effect of causing inflammation, which allows fluid to flow from blood vessels. Histamine also causes itching. Certain allergic reactions can create a dangerous condition called *asthma*, in which smooth muscle contractions reduce the size of air passageways in the lungs, making breathing difficult. Asthma attacks are usually triggered by particular antigens, and so the best response to the condition is to avoid that antigen. New drugs provide immediate relief from asthma attacks, relaxing the smooth muscle to make breathing easier. However, all drugs have side effects, some being worse than the disease they are purported to relieve. Interestingly, medical researchers, at the Foundation For The Simple In Medicine, report success in reversing asthma with a simple, but specific regimen of salt and water.


HIV patient showing a severe intraoral Karposi's sarcoma (cancer) lesion.

AIDS (Acquired Immune Deficiency Syndrome) is a disease caused by HIV (the Human Immunodeficiency Virus). This highly contagious virus is most prevalent among sexually active persons, particularly male homosexuals. The HIV virus attacks immune system cells. In particular, it reproduces inside Helper T cells and kills them in the process. As the disease progresses, which may take many years, HIV-infected individuals suffer one infection after another from organisms that the immune system normally controls with ease. Without Helper T cells to orchestrate things, the immune system eventually collapses and the victim dies of some other infection that the immune system would normally be able to handle. The most effective defense against AIDS is sexual abstinence before marriage and ***monogamy*** afterwards.

The immune system of the human body is immensely complex and you have learned a very small part of what has been discovered about this marvelous system. Scientists are amazed at the many different ways the body is designed to respond to disease-causing agents. Researchers are constantly discovering new things about the miraculous defense system of the human body.

**In the next lesson, we will begin a discussion of the remarkable human reproductive system.**

# LIFE PRINCIPLE



**"A wise man should consider that health is the greatest of human blessings, and learn how. . . to derive benefit from his illnesses."**

—Hippocrates (460-377 B.C.)
Greek physician and Father of Medicine



The Human Body

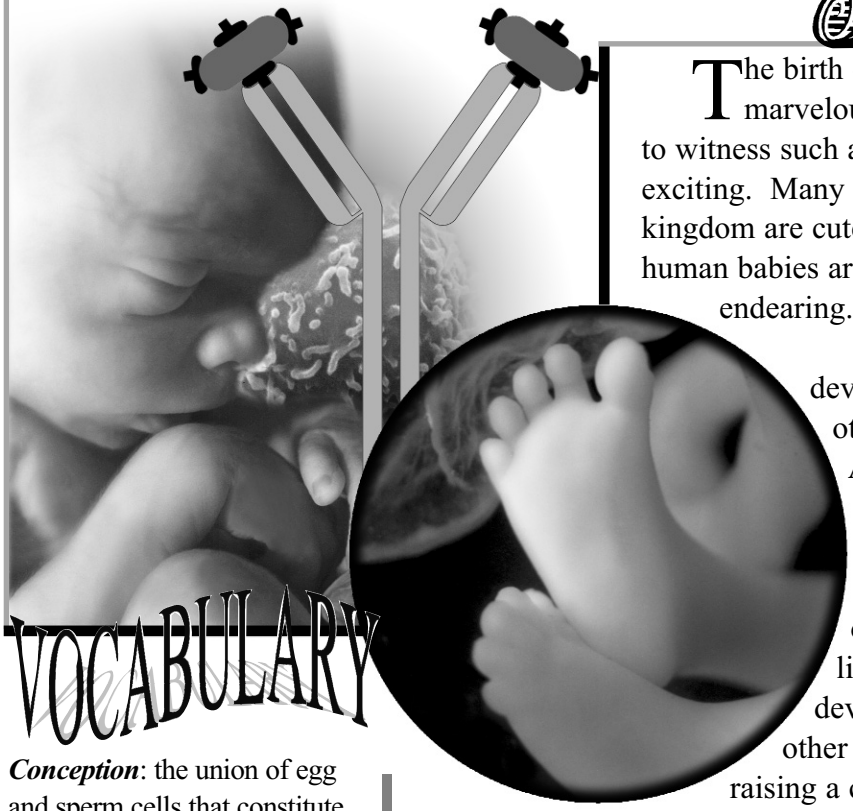
Lesson 13

# Chapter 2

## THE HUMAN BODY: THE REPRODUCTIVE SYSTEM—INTRODUCTION

## Section 3

*Lessons 11-15*



The birth of any creature is truly a marvelous and miraculous event, and to witness such a birth is memorable and exciting. Many infant creatures in the animal kingdom are cute and enjoyable to watch, but human babies are especially attractive and endearing.

Human reproduction and development is different from any other in the animal kingdom. Although most animal reproduction requires a female egg to be fertilized by a male sperm, only humans are designed with the element of life-long parental love and devotion. In addition, unlike any other animal species, properly raising a child usually involves at least eighteen years of parental care.

### VOCABULARY

***Conception***: the union of egg and sperm cells that constitute the beginning of a new person; when life as an individual begins

***Embryo***: a baby during the period of its growth from the fertilized egg up to 10 weeks after conception

***Gamete***: a mature (haploid) reproductive cell that can unite with another haploid cell to form a new individual; from Greek words for *husband*, *wife* and *marriage*

***Ovaries***: the female reproductive glands (gonads) that produce eggs and female hormones

***Testes or testicles***: male reproductive glands that produce sperm and male hormones

### Human Sexual Development

Although a birthday may celebrate the beginning of a child's life, biologists consider birth as the end of the process of reproduction. The trillions of cells in a newborn baby all derive from the fusion of two tiny reproductive cells: a sperm and an egg. Each contains vital characteristics necessary for life to begin at ***conception***.

During the first six weeks of development, male and female human ***embryos*** are almost identical. During the seventh week, however, the reproductive organs (which will eventually produce the reproductive cells called ***gametes***) begin to develop into either ***ovaries*** in females or ***testes*** in males.

As you have learned in a previous lesson, ovaries and testes are endocrine glands. The ovaries produce estrogens, which are a group of steroid hormones that cause the development of the female reproductive organs. The testes

## VOCABULARY

***Androgens***: the principal male steroid hormones, such as testosterone, which stimulate the development and maintenance of the male reproductive system and secondary sex characteristics

***Follicle-Stimulating Hormone (FSH)***: hormone secreted by the pituitary gland that stimulates the development of sperm in males and the follicle in females

***Luteinizing hormone (LH)***: hormone secreted by the pituitary gland that stimulates testosterone production in males and the development of the follicle, ovulation and production of the corpus luteum in females

***Seminiferous tubules***: tightly coiled tubules in males in which sperm cells are produced

***Vas deferens***: duct that extends from the scrotum to the ejaculatory duct

***Fallopian tubes***: one of the two tubes in the female reproductive system that receives the ovum (egg) from the ovary and passes it to the uterus; named after Italian anatomist Gabriel Fallopias (1523-1562) who described them

***Ovulation***: process in which an egg is released from the ovary; designed to occur about every 28 days

***Uterus***: muscular chamber in a female's reproductive system in which a fertilized egg can develop; also called the *womb*

***Cervix***: from the Latin word meaning *neck*; the neck-like opening at the end of the uterus adjoining the vagina; a baby passes through the cervix into the vagina during birth

***Vagina***: a thin-walled chamber that forms the birth canal and is the repository for sperm during mating

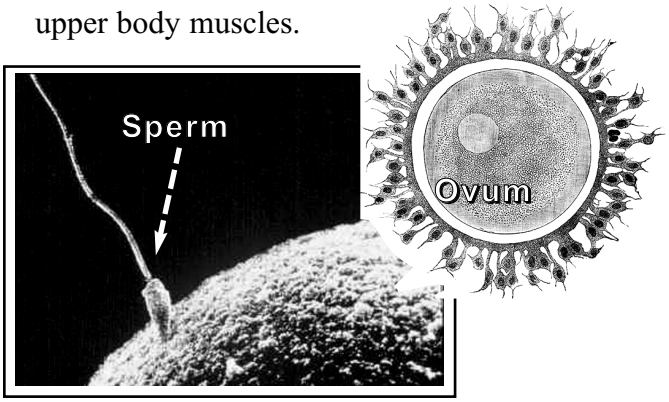
***Fetus***: the name given to a human embryo from about the third-month after conception until birth

produce ***androgens***, which are also steroid hormones that cause the male reproductive organs to develop. These hormones determine the sex of the developing embryo.

During childhood, the quantity of sex hormones is relatively low and is used to steer and shape physical development. As the child gets older, hormone levels begin to increase. The child enters puberty at about the time when the "12-year" molars emerge to signal adolescence. The reproductive organs become fully functional at puberty. Puberty begins when hormone levels increase. The hypothalamus releases substances that signal the pituitary gland to begin producing two hormones—***follicle-Stimulating Hormone (FSH)*** and ***Luteinizing Hormone (LH)***.

In males, LH signals certain cells in the testes to produce testosterone, the principal male hormone. FSH and testosterone are required for cells in the testes to develop into sperm. Each of these diploid (2n) cells undergoes meiosis, which results in 4 haploid (n) cells, each of which contains 23 chromosomes. After meiosis, these cells will develop into mature sperm cells with long flagella.

Testosterone is also responsible for the development of a male's secondary sex characteristics. During puberty, the male's voice deepens; he begins to grow body hair and begins to develop large upper body muscles.



In females, FSH and LH stimulate the ovaries to produce the female sex hormones, *progesterone* and *estrogen*, which are responsible for the development of female secondary sex characteristics, such as breast development and widening of the hips to facilitate child birth. In addition, these hormones work with FSH and LH to produce female gametes called *ova* (or eggs) in a monthly cycle. Each egg has 23 chromosomes so that when the egg and sperm fuse, the total number of chromosomes will be 46.

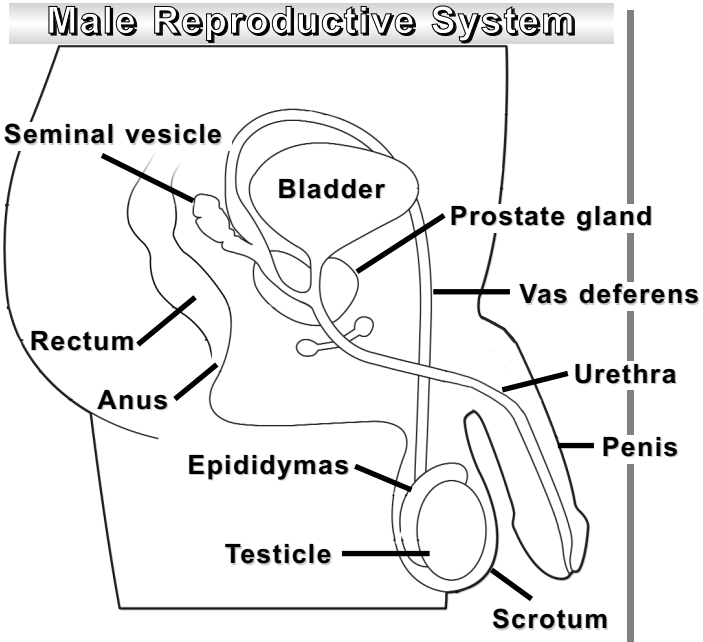
## Male Reproductive System

The male reproductive system has the task of producing and delivering sperm. Sperm are produced in the testes, which are contained in a sac called the *scrotum*, located outside the body cavity. This location keeps the temperature of the testes about $2^0$ C cooler than the rest of the body, which is important for sperm development.

The testes are made up of tightly coiled tubules called ***seminiferous tubules***. More than 100 million sperm cells are produced in the seminiferous tubules every day. When mature, the sperm travel into the *epididymis* for storage. When called into action, the sperm are released to the ***vas deferens***. Glands lining the reproductive tract, including the prostate, release a nutrient-rich fluid called *semen* in which sperm are suspended. Once the semen is made, it passes through the uretha within the penis and exits through the opening at the end of the penis.

## Female Reproductive System

The female reproductive system produces gametes in a much different manner. In contrast to the millions of sperm produced each day, the ovaries release, on average, just one egg every 28 days or so. Each time an egg is released from one of the ovaries, the rest of the reproductive organs prepare to nourish and support a developing embryo.

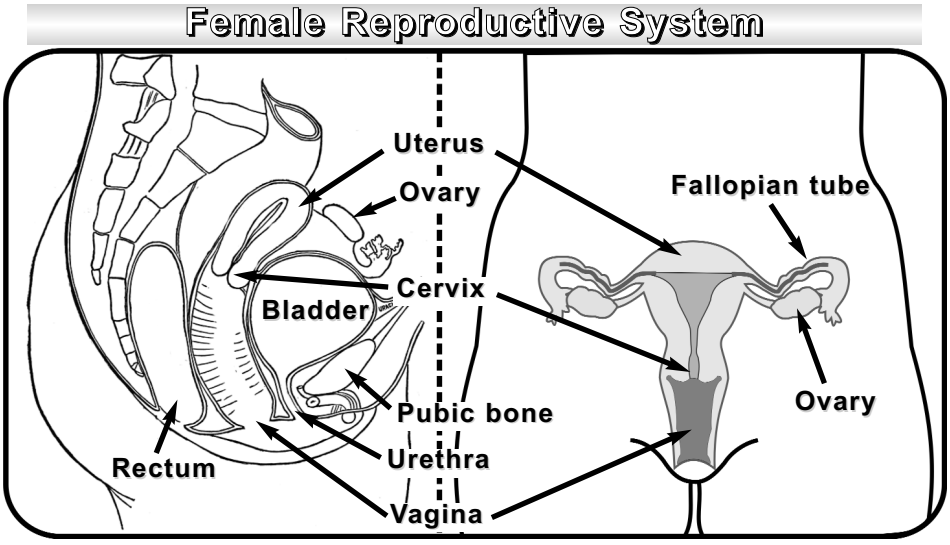



FSH stimulates the development of a *follicle*, which is a cluster of cells that contains a developing egg. The egg begins the process of meiosis and when complete, a single large haploid (n) egg results with three smaller cells called *polar bodies*, or polar cells, which simply disintegrate when their purpose is fulfilled.

While the follicle is developing, cells surrounding the egg produce increasing amounts of estrogen. When the level of hormones becomes critical, the follicle bursts and releases an egg into one of two ***Fallopian tubes***. The release of the egg is known as ***ovulation***.

The mature egg is slowly swept along the Fallopian tube by thousands of microscopic cilia. The journey takes a few days, after which the egg passes into a muscular chamber called the ***uterus***, designed to hold and nourish the young until birth. The outer end of the uterus is called

the ***cervix***. Beyond the cervix is a canal known as the ***vagina***, or *birth canal*, which is the passageway a ***fetus*** will travel during birthing.




**In the next lesson, we will study the monthly menstrual cycle and the process of fertilization.**

# LIFE PRINCIPLE



**"True love is to meet the emotional and physical needs of another person without expecting anything in return."**

—Bill Gothard
Author, founder of Institute in Basic Life Principles



The Human Body

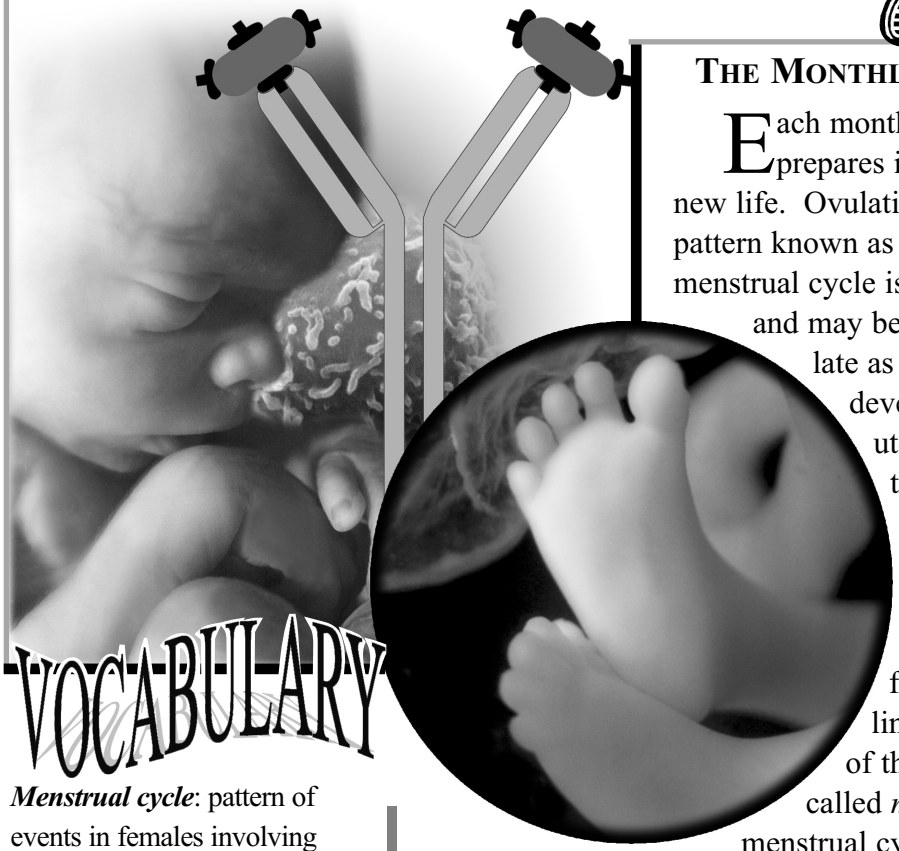
Lesson 14

# Chapter 2

## THE HUMAN BODY: THE REPRODUCTIVE SYSTEM—FUNCTION

**Section 3**

*Lessons 11-15*



### VOCABULARY

***Menstrual cycle***: pattern of events in females involving development and release of eggs for fertilization and preparation of the uterus to receive a fertilized egg

***Flux***: a Latin word meaning *flow*; a flowing of liquid from the body

***Follicle***: a small cavity or sac in the body; from the Latin word *folliculus*, meaning "small bag"

***Corpus luteum***: name given to the follicle after ovulation because of its yellow color

***Fertilization***: fusion of egg and sperm to form a zygote; conception

### THE MONTHLY MENSTRUAL CYCLE

Each month, the female's body prepares itself for the possibility of a new life. Ovulation is part of this monthly pattern known as the ***menstrual cycle***. The menstrual cycle is about 28 days in length and may begin as early as age 9 or as late as age 18. As an egg develops, the lining of the uterus is prepared to receive the egg. If the egg is fertilized after ovulation, it is implanted in the uterus as an embryo and begins development. If it is not fertilized, the egg and the lining of the uterus pass out of the body in a bloody ***flux*** called *menstruation*. The menstrual cycle has four phases.

### FOLLICLE PHASE

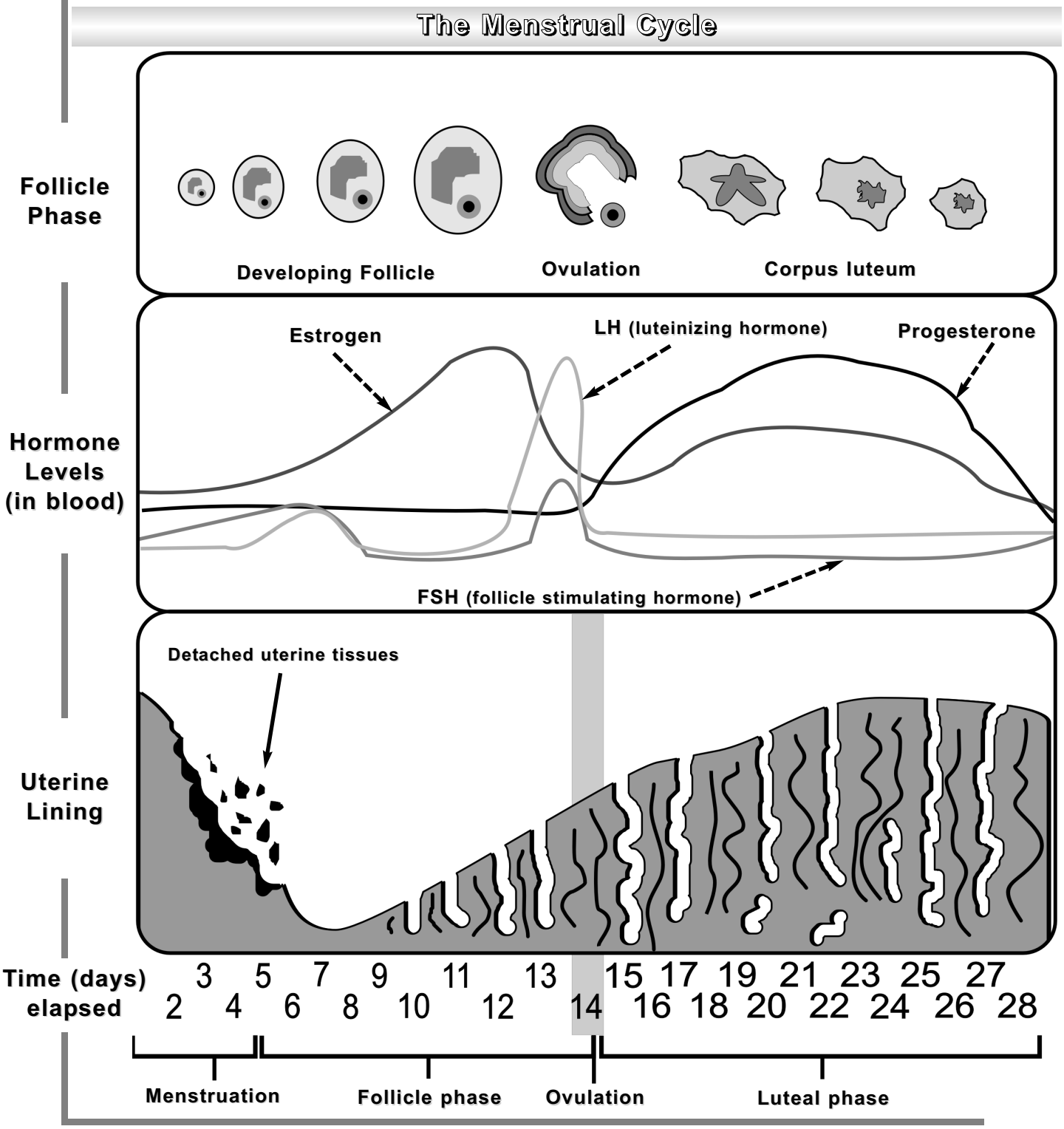
The *follicle phase* begins when the level of estrogen in the bloodstream is low. The hypothalamus senses the low level of estrogen and causes the pituitary gland to release FSH and LH into the bloodstream. These hormones act on the ovaries, stimulating a ***follicle*** to develop to maturity. As an egg develops, the cells of the follicle produce more and more estrogen. Estrogen causes the lining of the uterus to thicken in preparation for a fertilized egg.

### OVULATION

*Ovulation* occurs when the egg matures and the pituitary gland sends out a burst of LH. This causes the wall of the follicle to break open and the egg is released into one of the Fallopian tubes.

## Luteal Phase

The *luteal phase* of the cycle begins after the egg is released. As the egg passes through the Fallopian tube, the cells of the ruptured follicle turn yellow and become known as the ***corpus luteum***, which means "yellow body" in Latin. The cells of the corpus luteum continue to produce estrogen, but now produce large amounts of progesterone as well. *Progesterone*



stimulates cell and tissue growth in the lining of the uterus, preparing it for pregnancy. Progesterone also inhibits the release of LH and FSH. An egg has the greatest chance of being fertilized around the time hormone levels decrease.

## VOCABULARY

***Zygote***: from Greek words meaning *to be joined* or *yoked* together; a fertilized egg
***Morula***: solid ball of cells produced by cell division of a zygote; named from the Latin word for *mulberry* (due to its appearance)
***Blastocyst***: from the Greek word for *sprout*, meaning new, tender growth; the hollow ball of cells marking the phase of development of the zygote
***Implantation***: process during which the cells of a zygote grow into the uterine wall
***Human Chorionic Gonadotropin (HCG)***: hormone produced by the cells' zygote that keeps the corpus luteum alive and preserves the uterine lining
***Gastrulation***: process of cell migration during which the primary germ layers of the embryo are formed
***Germ cells***: gametes; living cells from which other cells develop; (have no connection to disease germs)
***Neurulation***: process by which the ectoderm forms the neural tube
***Neural tube***: the beginning of the nervous system that develops during neurulation
***Intrauterine***: within the uterus
***Placenta***: flat, spongy organ that connects a mother with her developing embryo and provides a place for the exchange of nutrients, oxygen, wastes and carbon dioxide
***Umbilical cord***: thin tube of embryonic tissue that connects the embryo to the uterus

### MENSTRUATION

*Menstruation* begins when the level of estrogen in the blood becomes so low that the lining of the uterus cannot be maintained. Tissues detach from the lining of the uterus and are discharged through the vagina, along with blood and the unfertilized egg. This phase usually lasts between 3 and 7 days. When it ends, a new cycle begins. The drop in estrogen that caused menstruation is sensed by the hypothalamus. It signals the pituitary gland to release FSH which starts the development of a new follicle and the cycle begins again. Menstrual cycles continue in a woman's life for 30 or 40 years, usually interrupted by health issues, pregnancies, or until the time of *menopause* which is defined as one full year without menstruation.

### FERTILIZATION

***Fertilization*** is normally achieved through sexual intercourse, during which the husband's penis is inserted into the wife's vagina. Muscle contractions cause an ejaculation of several millimeters of semen from the penis into the vagina. Semen contains as many as 100 million sperm per milliliter. The sperm swim through the uterus toward the Fallopian tubes; but of the millions released, only a few reach the Fallopian tube. If an egg is present in one of the tubes, fertilization will likely occur and the woman will become pregnant with child.

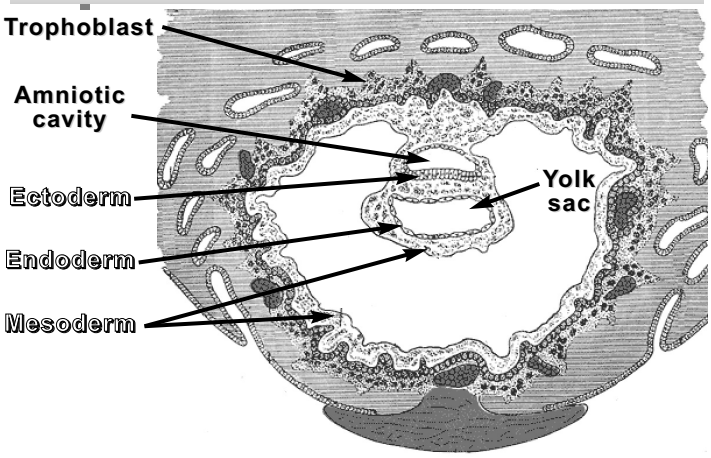
The egg is surrounded by a thick, protective layer. The outermost protective layer contains binding sites to which sperm can attach. When a sperm attaches to one of these sites, a sac at the end of the sperm breaks open, releasing powerful enzymes that dissolve the protective layer of the egg. Only one sperm will break through the barrier,

make contact with the egg cell membrane and fuse with the egg: a process known as *fertilization*. Immediately following this fusion, many changes take place within the egg cell membrane to prevent any other sperm from entering. The fused egg and sperm are now called a ***zygote***.

The newly formed zygote rapidly divides, forming a solid ball of cells known as a ***morula***. As cell division continues, the morula gradually develops a hollow cavity and becomes known as a ***blastocyst***. Three or four days after ovulation, the blastocyst attaches itself to the wall of the uterus. At this stage, the blastocyst does not depict human characteristics, but within a few months it will develop trillions of cells and recognizable human baby traits. The precision and intricacy of this process is amazing to behold. No human engineer has ever executed a plan more detailed and reliable. The most incredible aspect of this process is that the blueprints are written on the smallest possible scale—the DNA sequence in the nucleus of a single human cell.

The cells of the zygote proceed growing into the uterine wall in a process known as ***implantation***. This process causes the outermost cells of the zygote and the cells in the uterine wall to grow together to form structures that will nourish and support the developing embryo. Also, implantation produces chemical signals that preserve the uterine lining. As you recall, menstruation begins as hormone levels fall. To make sure this does not occur during pregnancy, the implanted zygote produces a substance called ***Human Chorionic Gonadotropin*** (HCG). HCG is a powerful chemical signal that keeps the corpus luteum alive and active. As a result, the uterine wall is preserved and the embryo has a safe place to grow and develop.

## The Developing Embryo




| Primary Germ Layer: | Will develop into: |
|---|---|
| **Ectoderm** | Eye lenses, hair, nervous system, epidermal skin layers, tooth enamel, lining of nose and mouth |
| **Mesoderm** | Dermal skin layers, muscular tissues, skeleton, gonads and circulatory system, connective tissue |
| **Endoderm** | Liver, pancreas, internal lining of respiratory and digestive systems |

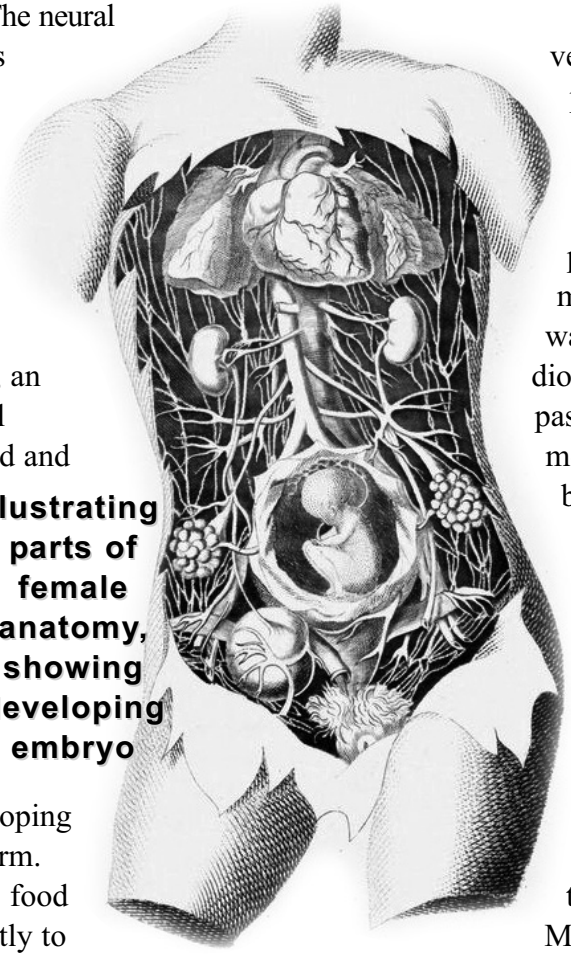
### The Developing Embryo

The early events of embryonic development are the same for most mammals. The outer layer of the blastocyst grows into the uterus, surrounding the tissues of the developing embryo. In a process called ***gastrulation***, three layers of ***germ cells*** become distinct—the *ectoderm*, the *mesoderm* and the *endoderm*. These are known as the primary germ layers of the embryo. All of the organs and tissues will be formed from these three primary germ layers. Another layer of cells in the blastocyst form two important membranes that surround the embryo. These are located outside the embryo and fill with fluid to help cushion the embryo and protect it from injury.

Near the end of the third week of development a critical event, called ***neurulation***, occurs during which time the

***neural tube*** is formed. The neural tube becomes the nervous system. One end of the tube will eventually develop into the brain, and the remainder of the tube will become the spinal cord.

Shortly after gastrulation is complete, an organ is formed that will supply the embryo's food and oxygen needs for the rest of its ***intrauterine*** development—the ***placenta***. During the fourth week of development, the ***umbilical cord***, through which the developing baby is fed, begins to form. You might think that the food and oxygen comes directly to the embryo from the mother. However, this could cause serious problems if the mother and embryo have different blood types. Therefore, the blood of the mother and embryo are designed never to mix.



**Illustrating parts of female anatomy, showing developing embryo**

Instead, they come into very close contact in the placenta. The placenta forms at the base of the umbilical cord. Tiny, embryonic blood vessels pass through pools of maternal blood. In this way, food, oxygen, carbon dioxide and metabolic wastes pass back and forth between mother and embryo, but the blood of the two do not mix. As the embryo grows, the placenta serves as its main organ of respiration, nourishment and excretion. Anything that the mother takes into her body, including drugs, alcohol and nicotine passes through the placenta to her baby. Most of the elements an embryo needs to grow into a healthy fetus and newborn child are supplied through the mother's diet.

**In the next lesson, we will examine fetal development and birth.**

# Life Principle



**"We must not (be). . . blind. . . to the fact that each moment of life is a miracle and mystery."**

—H.G. Wells (1866-1946)
English author & historian


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The Human Body

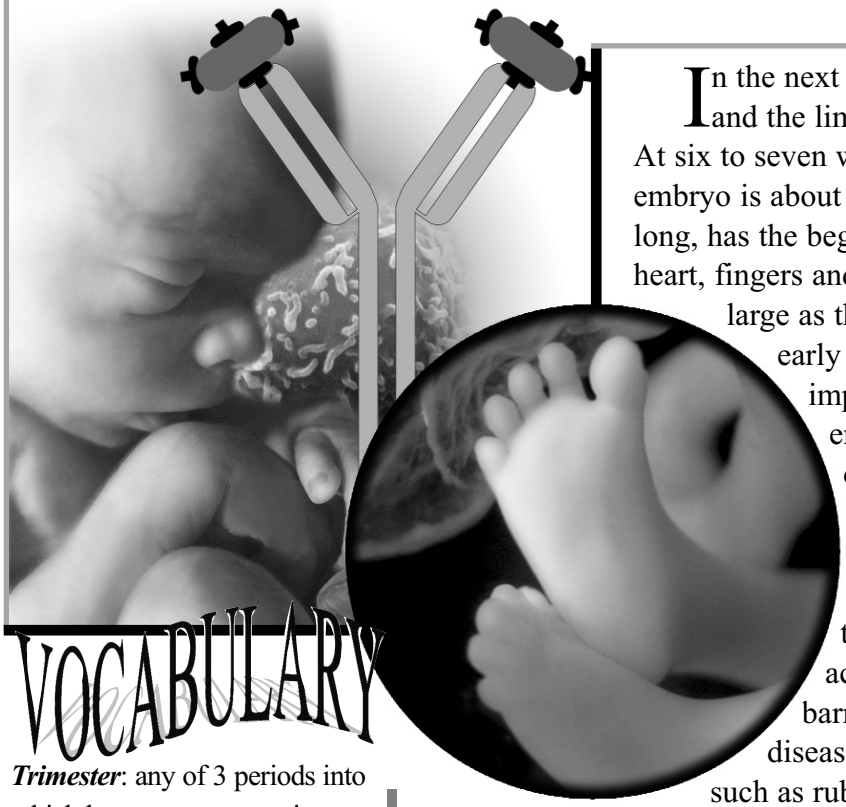
Lesson 15

# Chapter 2

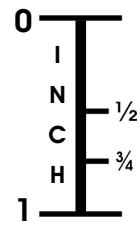
## THE HUMAN BODY: THE REPRODUCTIVE SYSTEM—FETAL DEVELOPMENT & BIRTH

**Section 3**

*Lessons 11-15*



In the next few weeks, the skeletal system and the limbs of the embryo take shape. At six to seven weeks after fertilization, the embryo is about one-half to three-fourths inch long, has the beginnings of eyes, a beating heart, fingers and a brain which is nearly as large as the rest of the body. These early weeks are a particularly important time for the embryo because a number of external factors can disrupt development at this point. Although the placenta acts as a barrier to some diseases, others such as rubella (German measles) and most drugs, including alcohol, tobacco and medications, can penetrate the placenta and prevent normal development of the vulnerable new being in the mother's womb.

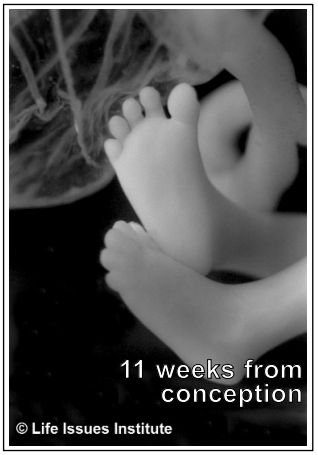






By the end of eight to ten weeks, the embryo is called a *fetus* and is unmistakably human. Its muscular system enables it to move around a little, and its




## VOCABULARY

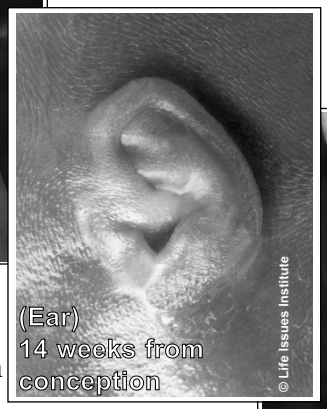
***Trimester***: any of 3 periods into which human pregnancy is divided:
first trimester (1-3 months);
second trimester (4-6 months);
third trimester (7-9 months)

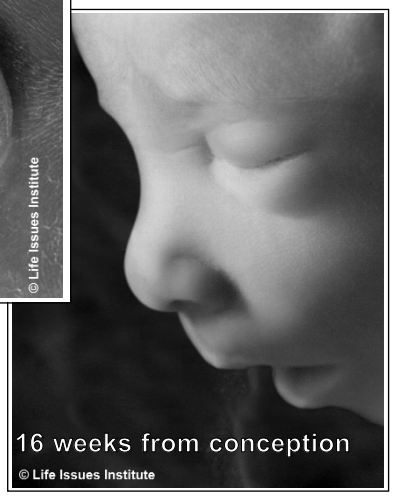
***Oxytocin***: pituitary hormone that stimulates contractions of the smooth muscles surrounding the uterus

***Prolactin***: pituitary hormone that stimulates the production of milk in the breast tissue of the mother

***Colostrum***: the fluid which comes before mature milk; contains a remarkable mixture of special antibodies produced by the immune system




sexual organs have developed to the point that doctors can distinguish a male from a female. Its heartbeat becomes loud enough to be heard through a stethoscope. It now begins to grow rapidly, and by the end of six months, or the second ***trimester***, it is nearly fourteen inches long and weighs between one and one-and-a-half pounds.

As the child enters its seventh month of growth (third trimester), reflexes in its nervous system enable it to respond to sudden noises. Its lungs are enlarging rapidly, and its digestive system is almost fully developed. Although a baby is quite developed at this point, if born now, the child is considered premature and will likely have serious health issues if it survives birth. In particular, the respiratory system is not fully matured, and many babies' systems are unable to regulate body temperature. Premature babies can survive, but must be given special care to increase their chances of survival.




## Stages of Labor

Normal childbirth takes place about nine months after fertilization. When natural birth is due, a hormone called ***oxytocin*** is released. This hormone stimulates contractions of the smooth muscles surrounding the uterus. Contractions occur slowly at first, introducing *first-stage labor* pains that feel like an onset of stomach cramps which usually "come and go" for a number of hours. Then uterine muscles begin a series of contractions known as *second-stage labor* which become more frequent and more powerful; the opening of the cervix expands until it reaches a diameter of nearly 10 centimeters, or about 4 inches. This extension of the mother's cervix is large enough for the head of the baby to be birthed. At some point during this time, the amniotic sac bursts and the fluid in the sac passes out of the mother's body. Pains are intense as "Mom" feels the urgency to push every few minutes to expel the fetus.

As a final push thrusts the baby through the mother's birth canal, a contraction occurs to squeeze the child's chest. This timely contraction causes the baby to cry, opening its fluid-filled lungs to take its first breath of air. Blood flow to the placenta dries up and it detaches from the wall of the uterus. The placenta will follow the baby out through the birth canal during *third-stage labor*, earning the placenta the title of


Expecting new life

"afterbirth". The umbilical cord is then tied and cut, leaving only a small piece attached to the baby. Within a few minutes, a wise doctor will place the newborn at the mother's breast to begin a life-long bond and to provide vital nutrients to the infant.


new born son

## Newborn Nourishment

Just a few hours after a child is born, a pituitary hormone known as ***prolactin*** stimulates the production of milk in the breast tissues of the mother. By breast-feeding her child as soon as it is born, the mother stimulates the release of more oxytocin, which also helps to stop uterine bleeding and return the uterus to its normal size. The mother's breast milk also passes an important secretion to the baby during the first few days. This fluid, called ***colostrum***, contains a remarkable mixture of special antibodies produced by the mother's immune system. Colostrum helps to ensure a properly functioning digestive system, minimizes potential allergy issues, and helps to protect the baby from infections for many weeks. Colostrum is gradually replaced by mature milk. The milk that humans and other mammals produce for their offspring is a complete food. It contains all the vitamins, minerals and other nutrients that the baby needs for the first several months of life. Informed doctors agree that breastfeeding provides the best nourishment for babies.


Proud Parents

## Beyond Infancy

The birth of a baby is a thrilling and exciting time for a mom and dad. Once the excitement of a new life wears off, parents face the reality of responsibility for rearing a child—not an easy task. Unlike other animal species, human parents are responsible for the physical, spiritual and emotional well being of a child for eighteen years or longer. Unfortunately, many children are reared in one-parent homes or blended families which severely complicate child-rearing issues. Children benefit most when both husband and wife are present in the home, responsibly performing their roles. Each parent performs different roles in a child's life. When both mother and father are available and working together as a loving team, the child has a far

greater probability of maturing into a responsible adult.

Although biologically and anatomically classified as animals, humans are greatly different from animals—not only in physical characteristics, but in many other ways. Humans have a spiritual dimension and mental processing abilities far above animals. Animals engage in four basic types of animalistic behavior: they eat, sleep, fight and breed. Humans are capable of a great deal more—of noble behavior, lofty aspirations, worship of their Creator and the ability to reason. Humans can reflect values and principles, and make mental judgments regarding acts of reproduction and child rearing responsibilities. A dog can be conditioned to stay in the yard, but he does not possess the ability to reason why. As a child grows, he or she develops intellectual skills and emotions far superior to any animal. Among human emotions is the capacity to love and be loved, and within every human is a natural desire to know about life. Likewise, people have a natural desire for, and knowledge about, the sexual act that produces offspring. However, sexual abstinence until marriage (and loyalty to your mate afterwards) is a wise choice—an act of moral courage and self-restraint that is the only true "safe sex". This allows both the man and woman to enter marriage with mutual respect and a clean conscience in anticipation of a life-long, satisfying marriage.

Anatomy and physiology is the study of the structure, function and relationships of your marvelous body components. Your task is to use these resources wisely.

### *The Problems of Anatomy*

*Where can a man buy a cap for his **knee***
*Or a key to the lock of his **hair**?*
*Can his **eyes** be called an academy*
*Because there are **pupils** there?*

*What gems are found in the crown of his **head**?*
*Who crosses the bridge of his **nose**?*
*Can he use when shingling the roof of his house*
*The nails on the end of his **toes**?*

*Can the crook on his **elbow** be sent to jail:*
*If so what can he do?*
*How does he sharpen his **shoulder-blades***
*I'm sure I don't know, do you?*

*Can he sit in the shade of the palms of his **hands***
*Or beat on the drum of his **ear**?*
*Does the calf on his **leg** eat the corn on his **toes**?*
*If so, why not grow corn on the **ear**?*

—Anonymous

# Life Principle



**"There are two ways to live your life: One is as though nothing is a miracle. The other is as though everything is a miracle."**

—Albert Einstein (1879-1955)
German-American scientist and mathematician