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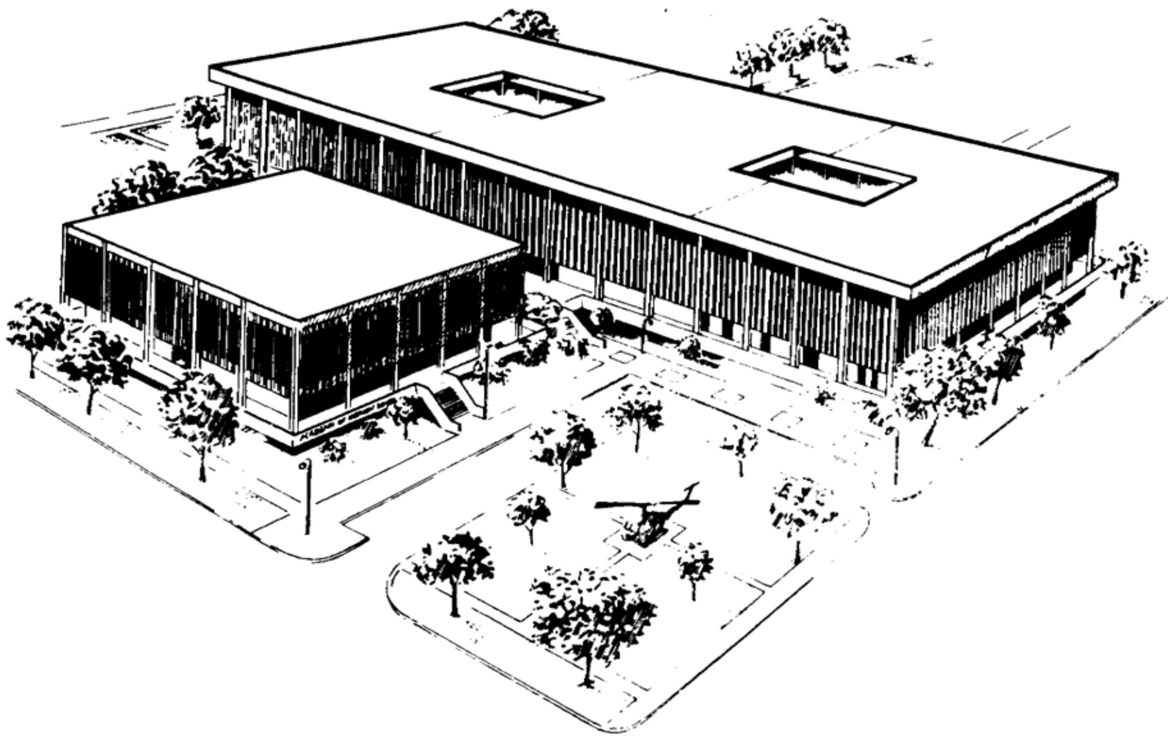

ANATOMY AND PHYSIOLOGY RELATED TO CLINICAL PATHOLOGY

SUBCOURSE MD0851 EDITION 100

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Figure 2-5 was extracted from Stanley W. Jacob and Clarice Ashworth Francone, Structure and Function in Man, 2d edition, 1970, chapter 11. Written consent of the copyright owner has been obtained. Under no circumstances will this material be sold, commercially used, or copied.

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CORRESPONDENCE COURSE OF THE
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0851

ANATOMY AND PHYSIOLOGY RELATED TO CLINICAL PATHOLOGY

INTRODUCTION

Anatomy and physiology are fascinating subjects to study. Even as you are reading this subcourse, many important reactions are occurring within your body. What types of reactions are occurring? What would happen if these reactions did not occur? Certainly each of these questions is important. Further, each of these questions will be examined in this subcourse. This subcourse is designed to give you a basic overview of anatomy, physiology, and pathology. It is the first in a series of subcourses that will provide you with the opportunity for expanding your knowledge in the sciences.

Remember, this subcourse is designed to be a basic introduction to these areas. If you desire additional information on a particular topic, you are urged to begin a self-directed study plan of your own. To this end, you may use additional references to research a specific area. Carefully complete this subcourse. The knowledge you gain from it will greatly help you to understand complex concepts that will be presented in future subcourses.

Subcourse Components:

This subcourse consists of two lessons and an appendix. The lessons and appendix are:

Lesson 1, Introduction to Anatomy, Physiology, and Pathology.

Lesson 2, Anatomy and Physiology.

Appendix, Glossary of Selected Medical Terms Used in the Subcourse

Credit Awarded:

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Section at Fort Sam Houston, Texas. Upon successful completion of the examination for this subcourse, you will be awarded 6 credit hours.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1 Introduction to Anatomy, Physiology, and Pathology.

TEXT ASSIGNMENT Paragraphs 1–1 through 1–17.

LESSON OBJECTIVES After completing this lesson, you should be able to:

1–1. Select the correct definitions of the terms related to anatomy and physiology.

1–2. Select the statement that best describes the function of a system of the body.

1–3. Select the most appropriate description of a structural component of a cell.

1–4. Select the component(s) of either deoxyribonucleic acid (DNA) or ribonucleic acid(RNA).

1–5. Select the best description of cellular protein synthesis.

1–6. Select the definition of the following terms: diffusion, Brownian movement, osmosis, isotonic solution, hypotonic solution, hypertonic solution, and active transport.

1–7. Select the best description of what would happen to a cell placed in either an isotonic, a hypotonic, or a hypertonic solution.

1–8. Select the correct mechanism(s) responsible for the absorption of tissue fluid.

1–9. Select the correct statement(s) for the cause(s) of edema.

1–10. Select the most appropriate description of a type of tissue.

1–11. Select the statement that best describes the function(s) of intercellular substance.

1–12. Select the correct definition of the term pathology.

1–13. Select the statement that best describes how a cause could produce a disease.

SUGGESTION

After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 1

INTRODUCTION TO ANATOMY, PHYSIOLOGY, AND PATHOLOGY

Section I. PRINCIPLES OF ANATOMY AND PHYSIOLOGY

1–1. INTRODUCTION TO ANATOMY AND PHYSIOLOGY

a. Anatomy is the study of the structure of the body. Often, you may be more interested in functions of the body. Functions include digestion, respiration, circulation, and reproduction. Physiology is the study of the functions of the body.

b. The body is a chemical and physical machine. As such, it is subject to certain laws. These are sometimes called natural laws. Each part of the body is engineered to do a particular job. These jobs are functions. For each job or body function, there is a particular structure engineered to do it.

1–2. ORGANIZATION OF THE HUMAN BODY

The human body is organized into cells, tissues, organs, organ systems, and the total organism.

a. Cells are the smallest living unit of body construction.

b. A tissue is a grouping of like cells working together. Examples are muscle tissue and nervous tissue.

c. An organ is a structure composed of several different tissues performing a particular function. Examples include the lungs and the heart.

d. Organ systems are groups of organs that together perform an overall function. Examples are the respiratory system and the digestive system.

e. The total organism is the individual human being. You are a total organism.

1–3. SYSTEMS OF THE BODY

A system is a combination of parts or organs which, in association, perform some particular function. The systems of the body and their functions are as follows:

a. **Integumentary.** Covers and protects the body from drying, injury, and infection, and also has functions of sensation, temperature regulation, and excretion.

b. **Skeletal.** Provides a framework for the body, supports the organs, and furnishes a place of attachment for muscles.

c. **Muscular.** Provides the force for the motion and propulsion of the body.

d. **Respiratory.** Absorbs oxygen from the air and gives off the waste product carbon dioxide produced by the body tissues.

e. **Cardiovascular.** Functions in the transportation of blood throughout the body.

f. **Lymphatic.** System of vessels and glands that returns protein and fluid to the blood from the various body tissues; also furnishes the body with protective mechanisms against pathogenic organisms.

g. **Gastrointestinal.** Digests and absorbs food substances and excretes waste products.

h. **Genitourinary.** Excretes and transports urine (urinary), and elaborates and transports reproductive cells and sex hormones (reproductive).

i. **Nervous and Special Senses.** Give the body awareness of its environment, and enable it to react to that environment.

1–4. NORMAL ANATOMICAL POSITION

The standard positioning of the human body (figure 1–1) has been chosen to be the erect (standing) position, with feet flat on the floor, upper extremities at the sides, and palms, toes, and eyes directed forward.

1–5. ASPECTS AND DIRECTIONS

a. **Anterior, Frontal, or Ventral:** refers to the front side of the body or toward the front.

b. **Posterior or Dorsal:** refers to the back or toward the back of the body.

c. **Medial**: toward or nearer the midline of the body (figure 1–1).

d. **Lateral**: away from the midline or toward the side of the body (figure 1–1).

e. **Proximal**: nearest to a point under consideration or the point of origin. In the case of the extremities, the articulations (joints) are considered points of origin (figure 1–2).

f. **Distal**: remoteness from a point under consideration or the point of origin; the opposite of proximal (figure 1–2).

g. **Superior**: above.

h. **Inferior**: below.

i. **Cephalad**: toward the head.

j. **Caudad**: toward the feet.

X is lateral to Y and Z; Y is medial to X and lateral to Z.

The body is shown in normal anatomical position.

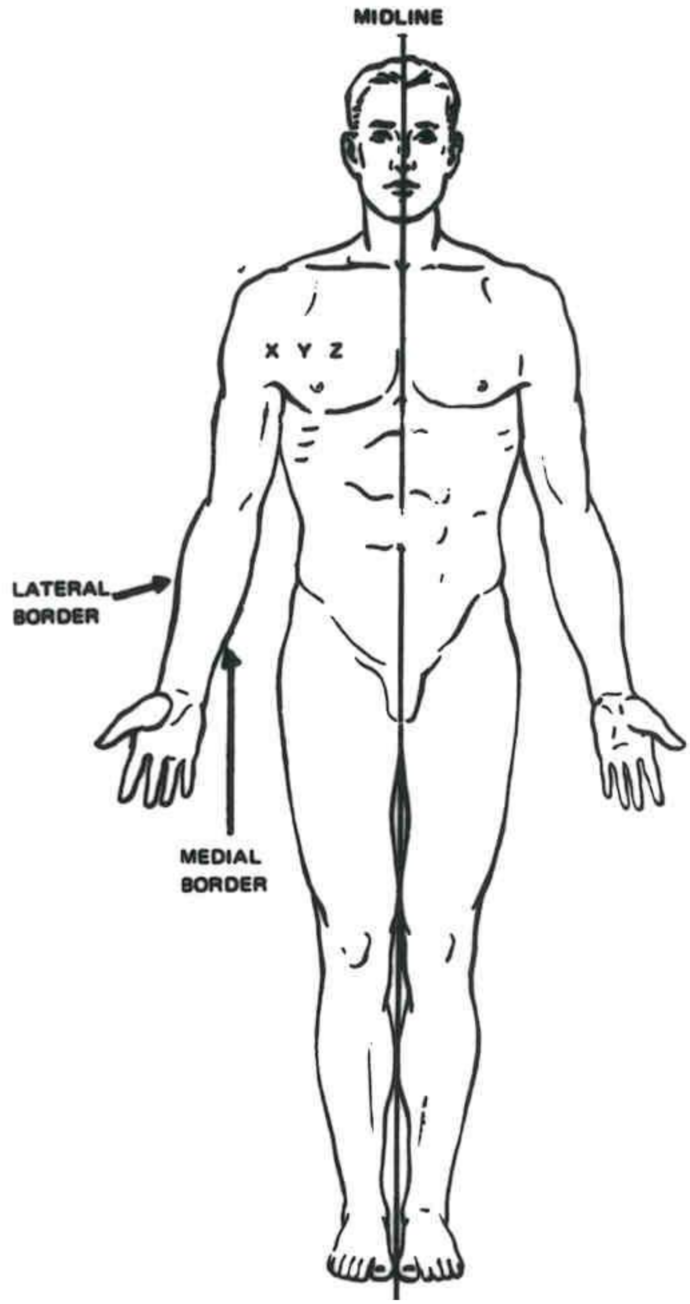


Figure 1–1. Medial–lateral relationships.

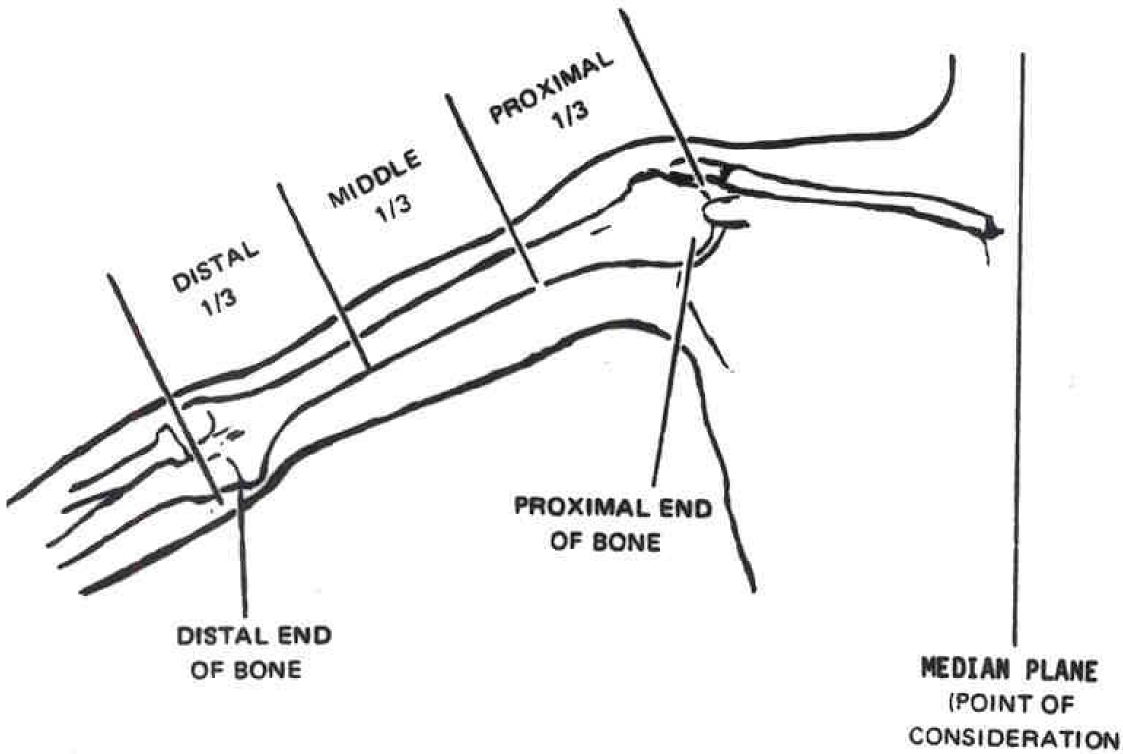


Figure 1–2. Proximal–distal relationships.

Section II. CELLS, TISSUE, AND TRANSPORT PROCESSES

1–6. INTRODUCTION TO THE CELL

A cell is the fundamental organizational unit of life capable of reproduction. Not long ago, the cell was considered to be a fairly simple structure that contained a nucleus and various enzymes. Today, however, the cell is known to be an extremely complex entity. With the advent of electron microscopy in the early 1940's, several distinct cellular structures called organelles were clearly recognized (figure 1–3). A typical animal cell contains the following structures: nucleus, nucleolus, nuclear membrane, centrioles, endoplasmic reticulum, golgi apparatus, ribosomes, mitochondria, lysosomes, vacuoles, and the cell membrane (unit membrane).

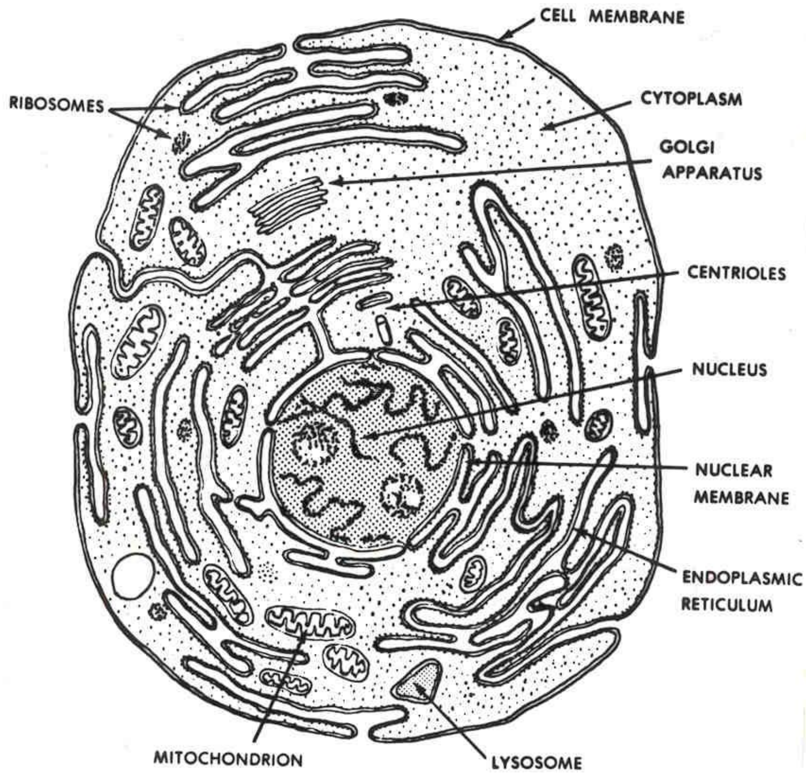


Figure 1–3. Schematic drawing of an animal cell.

1–7. STRUCTURAL COMPONENTS OF A CELL

a. **Nucleus.** The nucleus plays a central role because it is from this structure that information is distributed which guides the life processes of the cell. In particular, the nucleus plays a central role in cellular reproduction. Two types of structures found in the nucleus are chromosomes and nucleoli. Chromosomes are distinct only during cell division. They are composed of both nucleic acid and protein, and contain genes (basic hereditary units). Nucleoli are darkly staining ovoid bodies whose chief chemical constituent is ribonucleic acid (RNA). When protein systhesis is occurring in the cell, nucleoli are involved in interactions between the nucleus and cytoplasm.

b. **Centrioles.** Centrioles are found in pairs in the cytoplasm. They are cylindrical bodies oriented at right angles to one another. Their primary function is to assist in the division of the cell.

c. **Endoplasmic Reticulum.** The endoplasmic reticulum was so named because it was once thought to be confined entirely to the endoplasm (that part of the cytoplasm close to and surrounding the nucleus). It is now known to extend to the peripheral regions of the cell and is sometimes attached to the cell membrane. It is a complex network of thin membrane–bound cavities that vary considerably in shape.

These minute canals and vesicles (sacs) function as a kind of circulatory system to transfer materials throughout a cell. The endoplasmic reticulum functions in protein synthesis by serving as a site of attachment for the ribosomes, which in turn are the site of protein synthesis.

d. **Golgi Apparatus.** The golgi apparatus is similar to the endoplasmic reticulum in that it is a canalicular system. The surface membranes of the canals and vesicles, however, are always smooth. This greatly contrasts with the outer surfaces of the endoplasmic reticulum, which are frequently encrusted with rough granules. The function of the golgi apparatus is subject to debate, however, it is frequently associated with temporary storage of secretory materials and preparation of these for final secretion. The golgi apparatus may also synthesize certain compounds, for enzymes have been extracted from membranes of the complex.

e. **Cytoplasm.** The cytoplasm is the fluid or semifluid contained inside the cell membrane, but outside the nucleus. The cytoplasm functions as a medium to contain many substances; such as fats, proteins, glucose, water, and electrolytes. The clear fluid portion of the cytoplasm is called hyaloplasm. Located within the cytoplasm are the organelles that perform highly specific functions in the cell.

f. **Ribosomes.** Ribosomes are the site of protein synthesis and are referred to as "protein factories" of the cell. They are found either attached to the endoplasmic reticulum or in small groups in the cytoplasm called polyribosomes. A ribosome is composed mainly of RNA.

g. **Mitochondria.** Mitochondria are very dynamic and complex cellular structures. In living preparations, mitochondria are in constant motion and either vibrate in place or migrate to other portions of the cell. Mitochondria possess double membranes; the inner membrane has tiny projections called <u>cristae</u>, which extend into the lumen (hollow tube) of the mitochondria. Cristae greatly increase surface area within the organelle. Mitochondria are found in areas of greatest cellular activity and are commonly referred to as "powerhouses" of the cell. Almost every oxidative enzyme of the cell is present on the inner surfaces of the mitochondrion. Here nutrients and oxygen react to provide energy in the form of a substance called adenosine triphosphate (ATP). ATP molecules then diffuse throughout the cell and provide energy wherever it is needed for cellular functions. This process is known as cellular respiration.

h. **Lysosomes.** Lysosomes are small bodies containing hydrolytic enzymes. If lysosomes should suddenly rupture, autolysis or self–destruction of the cell occurs. However, when lysosomes function properly, they play an important role in intracellular digestion. For example, a lysosome can fuse with a food vacuole, and digestion occurs within the composite structure formed. Products of digestion can then be utilized by the cell.

i. **Vacuoles.** Vacuoles are best described as small storage areas for water, electrolytes, and food particles.

j. **Cell Membrane.** (Animal cells do not have cell walls; they have cell membranes only. Plant cells have both.) A cell membrane or unit membrane is quite complex, having the capacity to selectively absorb certain constituents from the cell's surrounding environment and release waste materials and other unwanted products into the environment. The precise ultrastructure of a cellular membrane is still under considerable debate. Its structure varies from one membrane to another, making it difficult to describe a typical unit membrane. It is generally accepted that a unit membrane consists of an inner and outer layer of protein with two layers of lipid in between.

1–8. THE STRUCTURE OF DEOXYRIBONUCLEIC ACID AND RIBONUCLEIC ACID

Prior to our discussion of protein synthesis, we will first discuss the structure of molecules responsible for producing proteins.

a. **Deoxyribonucleic Acid.** Deoxyribonucleic acid (DNA), like other large organic molecules, is composed of a relatively simple building block compound, called a <u>nucleotide</u>. A nucleotide includes three parts: a <u>phosphate group</u>, a five– carbon sugar called <u>deoxyribose</u>, and an organic <u>nitrogen–containing base</u>. There are four different types of nucleotides that occur in DNA, the type of each depending upon which of four nitrogenous bases are included in its structure. The four nitrogenous bases are <u>adenine</u>, <u>guanine</u>, <u>thymine</u>, and <u>cytosine</u>. Adenine and guanine are purine bases, characterized by a double–ring structure. Cytosine and thymine are pyrimidines, which have only a single ring. A typical DNA molecule is double–stranded and helical and has been simply described as appearing like a ladder twisted into a form of a helix (spiral). The sides of the ladder are composed of alternating molecules of phosphate and sugar while the rungs of the ladder are each composed of two nitrogenous bases. Since the width of the DNA molecule is the same, a purine base is always attached to a pyrimidine in forming a rung of the ladder like structure. More specifically, adenine is always bonded to thymine, cytosine to guanine.

b. **Ribonucleic Acid.** Ribonucleic acid (RNA), like DNA, is composed of a basic unit called a nucleotide. The RNA nucleotide is similar to the nucleotide of DNA in that it contains a phosphate group, a <u>ribose</u> sugar, and an organic nitrogen–containing base. The four nitrogenous bases include <u>adenine</u>, <u>guanine</u>, <u>cytosine</u>, and <u>uracil</u>.

c. **Differences.** Three main differences between DNA and RNA are:

(1) Deoxyribonucleic acid is double–stranded while RNA has one strand.

(2) Deoxyribonucleic acid contains deoxyribose; RNA contains ribose.

(3) Deoxyribonucleic acid contains thymine as one of its four nitrogenous bases while uracil has replaced thymine in RNA.

1–9. CELLULAR PROTEIN SYNTHESIS

Protein synthesis takes place on the surface of the ribosomes. The coded message is transcribed from the DNA to form messenger RNA (mRNA) in a process called transcription. The mRNA leaves the nucleus and attaches itself to the ribosomes. Each mRNA molecule is coded to establish the sequence of amino acids in at least one polypeptide chain. However, a smaller type of RNA, called transfer RNA, carries a specific amino acid and is capable of reading the amino acid code of the mRNA, is required to position each amino acid in the sequence dictated by the mRNA. This process is called translation. Once the amino acids are in the proper position, they combine to form peptide bonds with one another and at the same time detach themselves from the transfer RNA (tRNA) molecules. These tRNA molecules are then free to attach themselves to new amino acids that, in turn, are assembled in sequence on the mRNA.

1–10. DIFFUSION

The continuous movement of molecules among each other in liquids or in gases is called diffusion; the diffusion of solute particles is from an area of greater concentration to an area of lower concentration. The following are related concepts:

a. **Brownian Movement.** All molecules and ions in the fluids of the body are in constant motion. Each particle in solution moves in its own particular way. In 1828, Robert Brown observed under the microscope that during germination, pollen grains were in constant motion. The motion is now called Brownian movement, and it occurs in all types of fluids including those of the human body. Brownian movement is due to the collisions of the molecules of the dispersion medium (usually a fluid), against colloidal particles. This motion can sometimes be seen occurring inside a living cell. Brownian movement depends on the size of the particles and the viscosity of the medium. Rapidity of the movement is proportional to the temperature; the higher the temperature, the more rapid is the agitation and the greater the movement of the molecules.

b. **Molecular Collisions.** The motion of molecules never ceases. When a moving molecule hits another, it propels the second molecule. This striking of a second molecule decreases the energy of the first molecule and adds energy to the second molecule. Now the second molecule moves more rapidly than before, while the first molecule slows down in speed of movement. Molecules can be propelled first in one direction and then immediately in another. Figure 1–4 shows the movement of a single molecule during a fraction of a second. It shows the molecule being bounced off other molecules. Ions, molecules, and colloids diffuse in a similar manner; however, heavier particles diffuse more slowly than lighter ones.

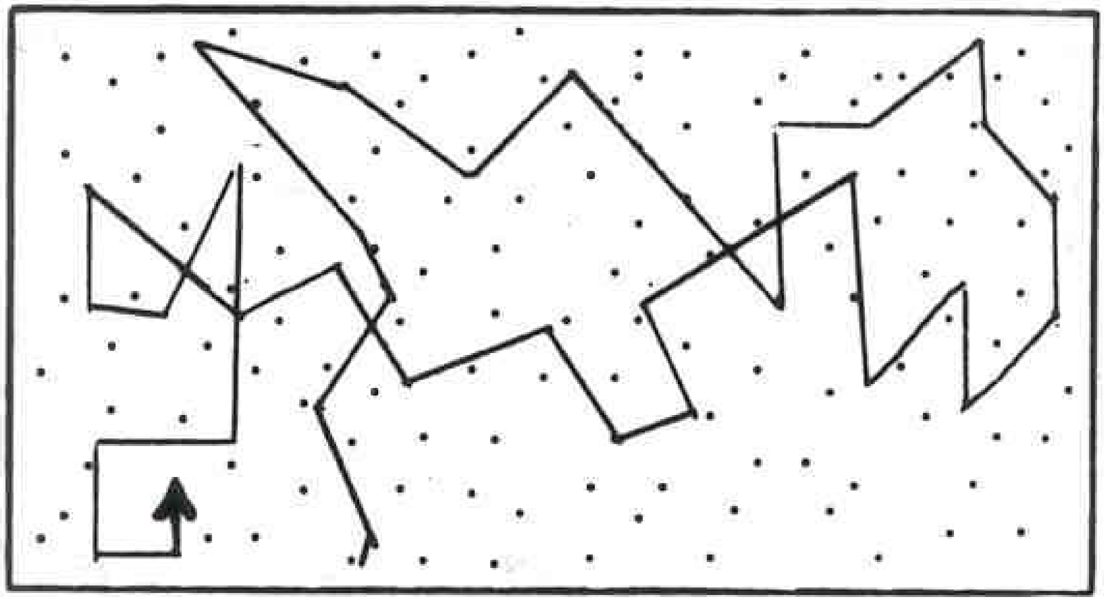


Figure 1–4. Diffusion of a molecule in a fraction of a second.

c. **Solvent and Solutes.** A solvent is a substance that is used to dissolve or uniformly disperse one or more other substances. A solvent is usually the liquid component of a solution and is present in greater amounts than the solute. It follows then, that a solute is that substance that is dissolved in a solvent. A solute is usually present in much smaller amounts than the solvent. An example would be a gram of salt dissolved in a liter of water. In this case, the water is the solvent and the salt is the solute. A solution may be composed of one or more solutes.

d. **Concentration Gradient.** The difference in concentration of a solute, on opposite sides of a membrane or from top to bottom of a centrifuge tube, is called the concentration gradient. When there is a concentration gradient, the solute tends to migrate from the area of higher concentration to the area of lower concentration, which tends to make the concentration equal in all areas. The size of the gradient is directly proportional to the net rate of diffusion of that solute.

1–11. OSMOSIS

a. **Definition**. Osmosis is the movement of solvent (usually water) from a solution of lesser solute concentration through a membrane to a solution of greater solute concentration. Figure 1–5 demonstrates the effect of osmotic pressure. The pressure of the water molecules entering the solution on the left must be counterbalanced by the hydrostatic pressure due to the increased height of the solution on the left. Once equilibrium has been achieved, the height of the solution may be used to determine its osmotic pressure. Osmosis can be used to understand actions of solutions of varying concentrations (interstitial fluids, plasma) on surrounding cells.

b. **Isotonic Solutions.** An isotonic solution is one in which the concentration of the surrounding fluid, and the osmotic pressure outside a cell, is equal to the concentration and the osmotic pressure inside the cell. The cell retains its original shape. The cytoplasm remains unchanged and there is no osmosis.

c. **Hypotonic Solutions.** When the concentration and osmotic pressure are lower in the surrounding fluid than in the cell, the cell begins to take up water, and the surrounding solution is said to be hypotonic. The cell begins to take up water by osmosis through a semipermeable membrane (the cell membrane) and greatly enlarges by swelling. When the fluid inside the cell becomes diluted sufficiently to equal the concentration outside the cell, further osmosis ceases (figure 1–6 A).

d. **Hypertonic Solutions.** When a cell is placed in a highly concentrated solution that has a higher osmotic pressure than that of the inside of the cell, the cell loses water from its cytoplasm and the surrounding solution is said to be hypertonic. Until the two concentrations are equal, water passes from the cell to the surrounding medium by osmosis (figure 1–6 B) and the cell shrinks.

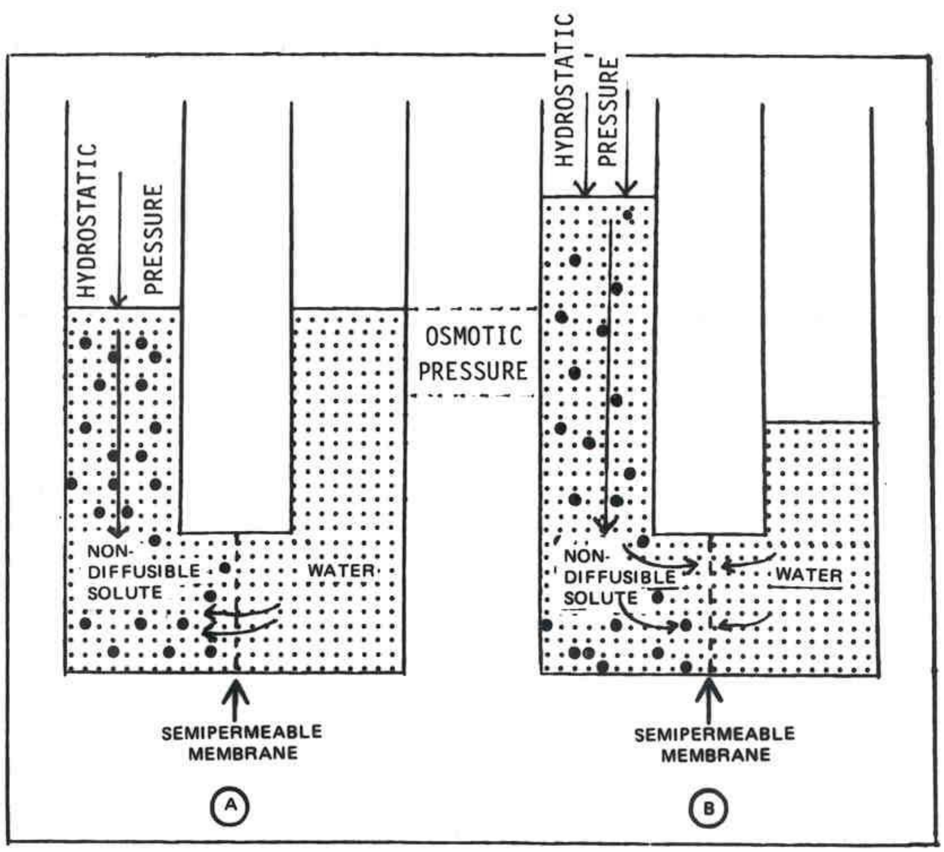


Figure 1–5. Osmotic pressure.

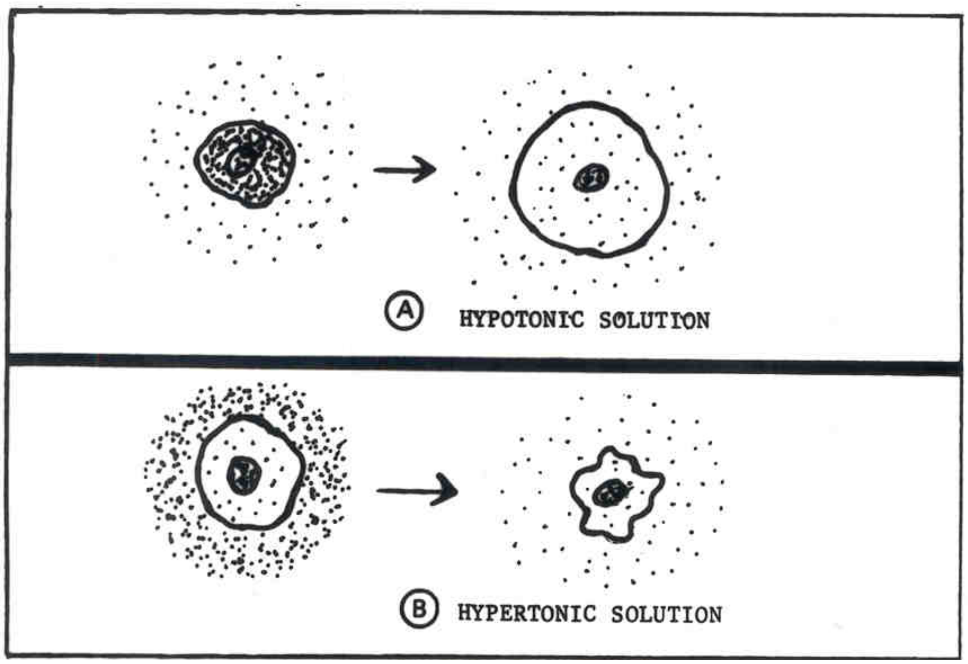


Figure 1–6. Diagram of the establishment of osmotic equilibrium when cells are placed in a hypotonic A or a hypertonic B solution.

1–12. ACTIVE TRANSPORT

Active transport means the movement of materials through the cell membrane by energy–requiring chemical processes rather than by simple diffusion.

a. **Energy Expenditure.** Active transport requires a considerable amount of energy for two reasons:

(1) Energy is required to initiate the carrier system and begin the chemical reactions.

(2) A considerable amount of energy is used to transport a substance from a medium of low concentration to one of high concentration. An example is the transport of potassium from the extracellular fluid to the intracellular fluid and sodium from intracellular fluid to extracellular fluid by the sodium/potassium ion pump.

b. **Concentration Control.** There exists a control mechanism that determines how much of a substance should be concentrated. This process also is genetically controlled.

1–13. TISSUE FLUID

a. **General**. Fluid outside the vascular system, bathing the cells, is interstitial fluid. This extracellular fluid that constitutes the liquid environment of cells is composed of the interstitial fluid and the circulating blood plasma. Capillaries provide a continuous living membrane that separates blood from the tissues. This semipermeable membrane permits the passage of water and crystalloids (see note below) from the blood, but does not permit the plasma proteins to pass through. Since most of the cells of the body lie outside of blood vessels, there must be a means of providing all of the cells with food materials and relieving them of their waste materials. The walls of the arteries are too thick to allow materials to diffuse through them. Arteries carry blood to the capillaries, and the thin walls of the capillaries allow water, food materials, and oxygen to nourish the individual cells. The relationship between the intercellular substance and the tissue fluid is different in different parts of the body. At some sites, where the intercellular substance is a sol, the tissue fluid is the medium in which the colloidal amorphous substance is dispersed. At other sites the amorphous substance exists as rigid gels.

NOTE: A crystalloid is a substance whose particles are small enough to pass through animal membranes.

NOTE: A colloid is similar to a solution; the suspended particles are too large to pass through an animal membrane but they are still so small that they do not settle out.

NOTE: A sol is a colloid system in which the particles are suspended in a liquid.

b. **Formation of Tissue Fluid.** Arteries are under a great deal of hydrostatic pressure, which would be an ideal means for pushing fluid out through the cellular wall. However, the walls of the arteries are so very thick, because they are under so much pressure, that no material can diffuse through them. In fact, these walls are so thick that the outer side must be fed by fluid from an outside source. Arteries feed into arterial capillaries. The walls of these capillaries are so very thin that the hydrostatic pressure within their arterial ends is sufficient to drive fluid out through the endothelium. The arterial ends of capillaries are the most important source of tissue fluid in the body.

c. **Absorption.** If tissue fluid were only produced and not absorbed by some mechanism, the body would swell enormously. There are two mechanisms that together absorb tissue fluid at the same rate that it is produced.

(1) <u>Venous ends of capillaries</u>. The hydrostatic pressure of the capillaries must be great enough to force fluid out when another factor is seeking to draw tissue fluid back into the capillary. The attraction that blood has for tissue fluid is due to the fact that the osmotic pressure of blood is slightly higher than that of the tissue fluid. Hydrostatic pressure is greater at the arterial side of the capillary so fluid is forced out at this point. At the venous end of the capillary, the osmotic pressure of the blood is greater than the hydrostatic pressure of the capillary; thus, tissue fluid is absorbed.

(2) <u>Lymphatics</u>. That portion of tissue fluid that is not absorbed by blood capillaries is collected by the lymphatics, and once it has gained entrance here, it is known as lymph. These lymphatic vessels drain into larger vessels and eventually into two main trunks that return all the lymph into large veins near the heart. A little colloid

escapes from the blood vessels into the tissue fluid. Colloid cannot diffuse back into the blood vessels, but it can enter the lymphatics and be carried away. If it were not for the lymphatics, colloid would accumulate in the tissue fluid and begin to hold water. The lymphatics and lymphatic fluid, therefore, help control the volume of tissue fluid.

d. **Edema.** A swelling of tissue due to an excess of tissue fluid is called edema. The cells and structures within the tissue are greatly spread apart in this condition. The amount of stretching from within is different in various tissues. Tissue edema is rather self–limiting in that when a certain point is reached, the hydrostatic pressure of the fluid in the stretched tissue is almost as great as that of the capillaries. Because of this, the formation of tissue fluid is almost stopped. As the tissue swells, the lymphatic vessels are pulled apart to keep them open. Some of the causes of edema are as follows:

(1) <u>Increased hydrostatic pressure in blood capillaries</u>. A buildup of hydrostatic pressure in the capillaries is almost always due to some obstruction to the free drainage of blood into the veins and back to the heart.

(2) <u>Lymphatic obstruction</u>. Since some of the tissue fluid is drained off by the lymphatics, any obstruction to the lymphatic system would lead to an increase in tissue fluid.

(3) <u>Insufficient colloid in the blood</u>. The fact that fluid is absorbed at the venous end of capillaries depends on the increased osmotic pressure of the blood. Since the increase of osmotic pressure in the blood is due to the colloid content, any depletion of the colloids would result in a lower osmotic pressure. The colloids of the blood are proteins. Protein starvation would deplete the colloids and result in edema. A draining off of proteins also occurs in certain diseases of the kidneys and proteins are passed out in the urine. Large amounts of protein can also be lost by their seeping away from large injured areas.

(4) <u>Increased permeability of blood capillary endothelium</u>. Endothelial membranes are composed of living tissues. Because they are living, they keep colloids from diffusing into the tissue fluid. If capillaries become injured, they will permit colloids to escape into the tissue fluid. When colloids leak out of the capillaries, they raise the osmotic pressure of the tissue fluid until it becomes the same as that in the capillaries. When they become equal, tissue fluid is not returned at the venous ends of the capillaries and tissue fluid builds up. If capillary injury is over a large area, a condition develops known as surgical shock. There is only a certain amount of fluid in the vessels of the circulatory system. It is possible, with a massive injury, to deplete the circulatory system to the point where it can no longer function. As the plasma continues to escape, there is less and less fluid, with the result that the chambers of the heart do not fill properly between heart contractions. The result is collapse of the circulatory system and death.

1–14. TYPES OF TISSUE

a. **Tissues**. A tissue is composed of a group of cells that are the same or similar in nature. The various tissues of the body have different characteristics because the cells that make up these tissues are different both in structure and function. There are four primary types of tissues: epithelial, connective, muscular, and nervous.

b. **Epithelial** (figure 1–7). Epithelial tissue covers the outer surface of the body and forms the lining of the intestinal and respiratory systems. A special form called <u>endothelium</u> lines the heart and blood vessels. As <u>serous membranes</u>, it lines the cavities of the abdomen, the chest, and the heart, and covers the organs that lie in these cavities. Epithelial tissue forms the <u>glands</u> and parts of the <u>sense organs</u>. According to its location, this tissue has different functions. As the skin, it protects underlying structures; in the small intestine, it absorbs; in the lungs, it is a highly permeable membrane; in glands, it secretes; and in the kidneys and liver, it both secretes and excretes. There are three types of epithelial tissue based on the shape of the cells. These are squamous (flat), cuboidal, and columnar. These cells are further designated as <u>simple</u> if they are arranged in a single layer, or <u>stratified</u> if arranged in layers.

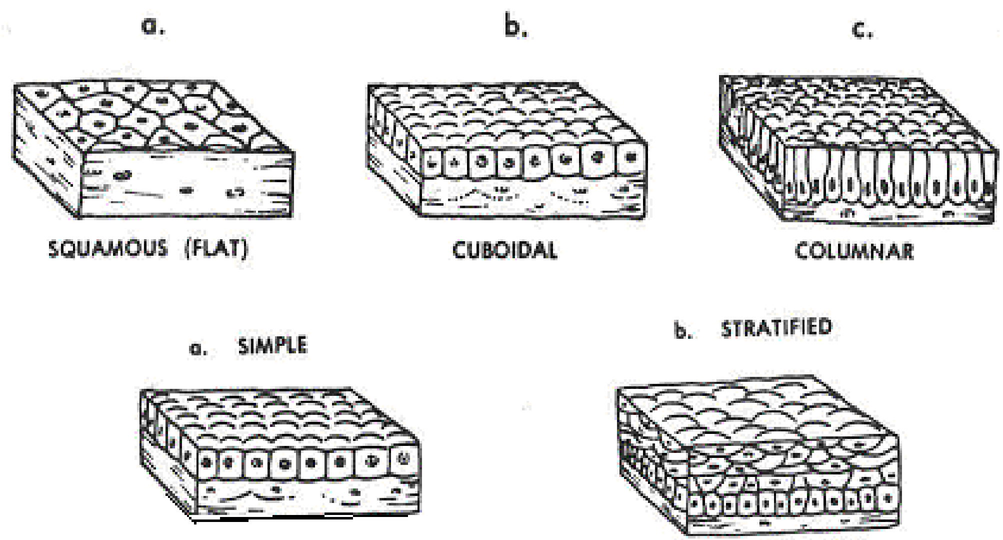


Figure 1–7. Epithelial tissue.

c. **Connective**. Connective tissue (figure. 1–8) is very widely distributed throughout the body. It binds other tissues together and supports them, forms the framework of the body, and repairs other tissues by replacing dead cells. Principal types of connective tissue are osseous (bony), cartilaginous, fibrous, elastic, and adipose (fatty). <u>Areolar</u> tissue, which lies under the skin and serves to fill many of the sharp corners and small spaces of the body, is a mixed type composed of fibrous, elastic, and fatty connective tissue.

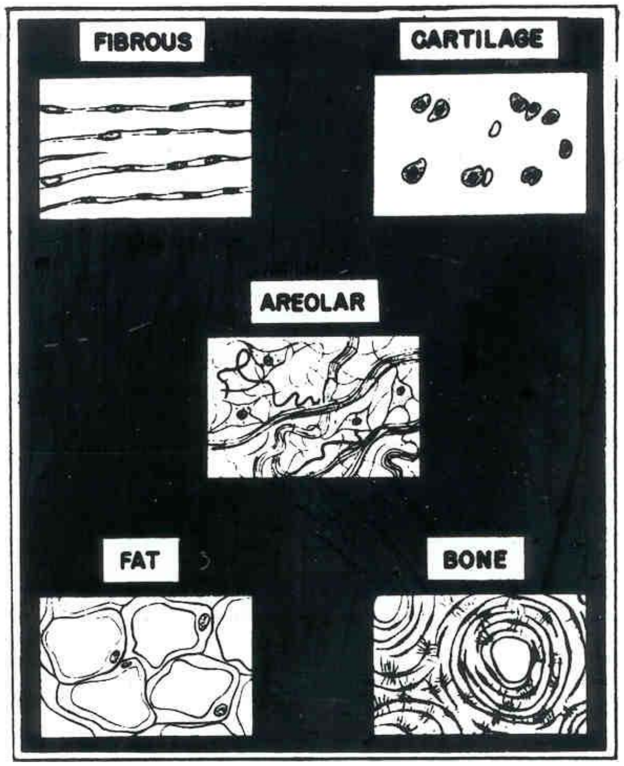


Figure 1–8. Connective tissue.

d. **Muscular**. This tissue is of three kinds: skeletal (striated, voluntary), smooth (involuntary), and cardiac (see figure 1–9).

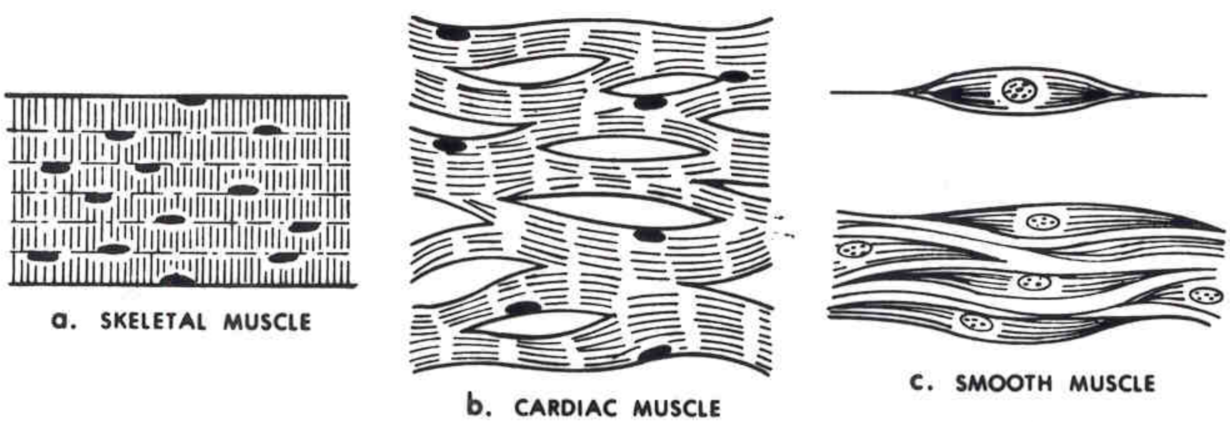


Figure 1–9. Muscular tissue.

e. **Nervous**. This tissue is made up of nerve cells (neurons) and the supporting structure (neuroglia) (see figure 1–10).

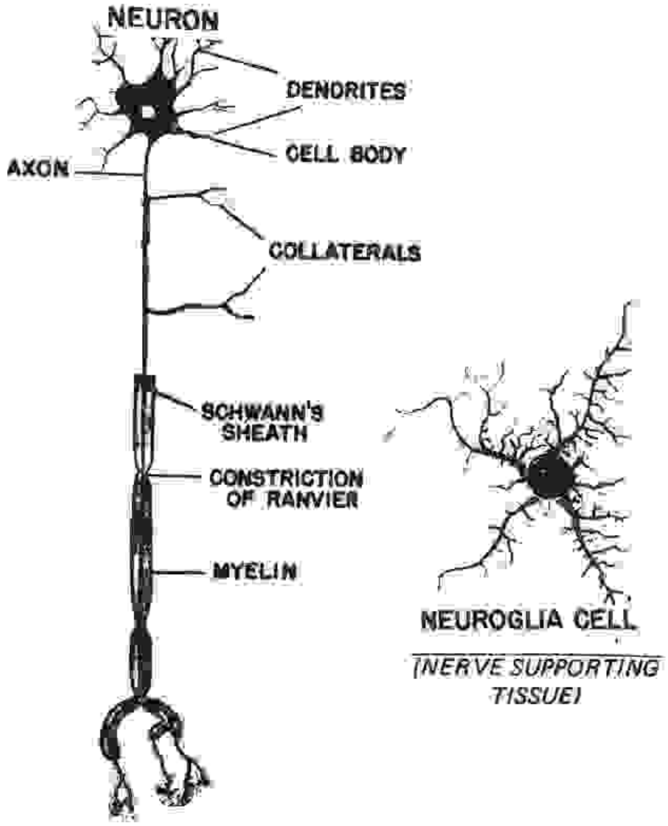


Figure 1–10. Neuron and neuroglia.

1–15. INTERCELLULAR SUBSTANCE

a. **General**. Intercellular substance, found between living cells, consists of nonliving material produced by living cells. The intercellular material may be considered a type of building material that gives form to various parts of the body, as well as to the body as a whole. Intercellular substance, which is found predominantly in connective tissue, is either fibrous or amorphous.

b. **Functions.** The following are functions performed by intercellular substance:

(1) Strength and support. Intercellular substance provides strength and support for the tissues. This function is performed mostly by the fibrous types of intercellular substance. Amorphous substance in the form of very stiff gels also helps add strength and support to tissues.

(2) Medium for tissue fluid. Intercellular substance is frequently found between capillaries and the cells that are nourished by these capillaries. For food substances to be transferred from the capillaries to the cells, it is necessary that this food substance pass through the intercellular substance. It is, therefore, an important function of the intercellular substance to provide a medium through which materials may be transferred from capillaries to the cells and back again.

(3) Resistance to infection. The presence of intercellular substance creates a buffer zone to help prevent the spread of infection from cell to cell. However, some bacteria produce an enzyme (hyaluronidase) that is capable of breaking down one of the chief constituents of intercellular substance (a mucopolysaccharide called hyaluronic acid), thus reducing the viscosity of the intercellular substance and enabling an infection to spread.

c. **Fibrous Intercellular Substance.** There are three kinds of formed intercellular substances that are fibers: collagenic, reticular, and elastic. Chemically, these fibers are a great deal alike since they are all albuminous proteins. This group of proteins is characterized by their insolubility in neutral solvents.

d. **Amorphous Intercellular Substance.** The ground substance of connective tissue is a nonfibrillar amorphous substance that varies from a fluid–like, to a gel–like, to a firm intercellular cement. When in a liquid state, the ground substance should not be confused with interstitial fluid, which originates from blood plasma. The amorphous material is chiefly composed of mucopolysaccharides. Cartilage is composed predominantly of mucopolysaccharides. As calcium salts deposit in mucopolysaccharides, bone is formed.

Section III. INTRODUCTION TO PATHOLOGY

1–16. DEFINITION OF PATHOLOGY

Pathology is the study of disease. Disease can be defined as a derangement of the normal functioning of one or more of the body processes. This interference with the normal body functions either prevents them from taking place, or causes them to act in an abnormal manner. For example, a tumor may obstruct the flow of intestinal contents, or bacteria may cause irritation or inflammation. In the following text, consideration will be given to those factors that are responsible for interference with the normal body functions, in other words, the etiology (causes) of disease.

1–17. CAUSES OF DISEASE

There are nine major causes of disease (a through i below). Frequently, a disease may be produced by a combination of these causes, or the same disease may be caused by different factors in different patients, or the cause may be unknown (j below).

a. **Prenatal Influences.** By this is meant those factors that may operate before birth to produce disease in the offspring; factors may be manifested at birth (congenital disease) or may not become obvious until later in life.

(1) Heredity. Among prenatal factors, one influence is heredity. A disease may be genetically transmitted from a parent to offspring. The parents who transmit the disease to their offspring may or may not have the disease themselves. Examples of some common hereditary diseases are hemophilia and congenital dislocation of the hip.

(2) Congenital influence. Diseases affecting the mother while she is pregnant with the baby may adversely affect the offspring also. For example, some diseases may be transmitted directly to the baby via the blood–stream, as is often seen in the case of syphilis in the mother. Or the pregnant woman may have a disease such as German measles (rubella), which interferes with the normal development of the child in the uterus (in utero), even though the child does not acquire the disease. Malnutrition in the mother could result in a poorly nourished baby and thus, possibly, an abnormally developed child.

(3) Mechanical. Purely mechanical factors are also felt to be responsible for some abnormalities present at birth. Abnormal positioning of the baby in utero is felt to be occasionally responsible for wryneck; torsion or twisting of the umbilical cord would limit the blood and food supply to the baby, and dire results could occur. Any defect or disease present at the time of birth is called a congenital disease or condition. Injuries or effects sustained during the process of being born may be included here.

b. **Parasites.** Parasites are organisms that live on or within the body of man or any other living organism, and at the expense of the one parasitized. Parasites may live on the surface of the skin (ectoparasites), or they may enter the body through the skin, the respiratory tract, the gastrointestinal tract, or the genitourinary tract where they may enter the blood stream and be carried to distant parts of the body. If they live inside the body but outside the cells, they are called extracellular endoparasites; if they enter the body's cells, they are called intracellular endoparasites. They all cause disease by interfering with the tissue and organ functions; they accomplish this by elaborating toxins, or poisons; by causing inflammation, or irritation; by producing enzymes that destroy tissue; and by causing mechanical blockage of function.

(1) Viruses. These are the smallest agents known to produce disease; whether they are living organisms or complex chemical compounds is not known. They are known to be intracellular endoparasites that cause such common diseases in man as poliomyelitis, common cold, influenza, measles, mumps, chickenpox, smallpox, hepatitis, encephalitis, warts, rabies, yellow fever, and lymphogranuloma venereum.

(2) Rickettsiae. These organisms are larger than viruses, but are still very small, intracellular endoparasites. These organisms are transmitted to man by mites, ticks, fleas, or lice, and they produce Rocky Mountain spotted fever, typhus (epidemic and endemic), scrub typhus (tsutsugamushi fever), Q fever, and Rickettsialpox.

(3) Bacteria. Bacteria are minute, one–celled, organisms that may occur alone or in large groups called colonies. Significant bacteria can be divided by their shape into three main groups.

(a) Cocci. Cocci are round, one–celled bacteria. The primary members of this group are staphylococci that group themselves in clusters, streptococci that arrange themselves in chains, and diplococci that arrange themselves in pairs.

(b) Bacilli. Bacilli are rod–shaped; however they vary from straight to irregular–curved and branched–shapes. They cause such common diseases as typhoid fever, diphtheria, tuberculosis, and leprosy.

(c) Spirochetes. Spirochetes are spiral–shaped and can move or twist. Spirilla and Treponema pallidum are examples. The latter causes syphilis.

(4) Fungi. These extracellular endoparasites or ectoparasites are larger and higher in the scale of plant life than are the bacteria. They include the yeasts and molds, and produce infections of the skin such as ringworm, and infections of the mucous membranes such as thrush. Some attack internal organs, especially the lungs and central nervous system, very often with disastrous results.

(5) Protozoa. These are one–celled animal parasites (either extracellular or intracellular) that cause such common diseases as malaria and amoebic dysentery.

(6) Metazoa. These many–celled, larger animals include the helminths (worms) such as the ascaris, the hookworm, the pinworm, the tapeworms, and the flukes, as well as the arthropods (mites, lice, and so forth).

c. **Intoxicants.** Taking into the body any chemical substance that causes disease or injury is known as intoxication. Many substances are very useful in small amounts, and do not cause intoxication, but the same substances may be very toxic in larger amounts, and result in severe illness or death.

d. **Trauma.** Trauma may be defined as injury sustained by the body as the result of a physical agent or force. The physical agents that may produce trauma or injury of the body are:

(1) Light. In excessive amounts, light can cause temporary blindness.

(2) Heat. Excessive heat can cause burns of the body, heat cramps, heat exhaustion, or heatstroke.

(3) Cold is absence or deficiency of heat. Exposure to low temperatures can result in frostbite and other cold injury.

(4) Electricity. One can sustain burns, electric shock, or both when exposed to this agent.

(5) Ionizing radiation. Excessive exposure to x–rays or to radio– active elements can produce burns, radiation sickness, malignancies, cataracts of the eye, and genetic changes.

(6) Mechanical forces. These agents produce contusions (bruises), abrasions (scrapes), lacerations (cuts), fractures, sprains, and strains.

(7) Sound. Exposure to excessive noise can cause temporary or permanent deafness to certain wavelengths.

e. **Circulatory Disturbances.** Any interference with the blood flow to a portion of the body results in a circulatory disturbance.

(1) Ischemia. A decrease in the normal diameter of an artery supplying a portion of the body results in a decrease in the amount of blood that flows to that part. The area becomes paler and colder than normal, and is said to be ischemic.

(2) Thrombosis. Whenever a vessel wall becomes diseased, the blood tends to collect at the diseased or injured site and form a thrombus (clot). The presence of an intravascular blood clot is called thrombosis.

(3) Embolism. Portions of a thrombus may break loose, and then travel freely in the bloodstream until stopped by a vessel too small for the particle to pass through; or foreign particles, such as air bubbles or fat globules, may be introduced into the bloodstream and travel freely until stopped by a smaller vessel. These foreign particles are known as emboli. The process of obstruction or occlusion of a blood vessel by a transported foreign material is known as embolism.

(4) Gangrene. When an extremity or portion thereof loses its arterial blood supply as the result of thrombosis, embolism, trauma, or from any other cause, a massive area of the tissue dies, and is said to have undergone gangrene, or to have become gangrenous.

(5) Infarction. Death of the tissue of an organ or portion thereof as the result of the loss of its blood supply is known as infarction. The necrotic (dead) area itself is called an infarct.

(6) Hemorrhage. This is the loss of blood.

f. **Neuropsychiatric Disturbances.**

(1) Organic disorders. Injury or disease of the nervous system tissue may result in the loss of the nerve supply to a particular part of the body, and as a result of the loss of innervation, secondary changes in the tissue occur, such as atrophy. Also, the normal functions may become paralyzed and there may be loss of sensation and other changes.

(2) Functional disorders. Disturbances of the mind or psyche may produce neuroses, psychoses, or character and behavior disorders. Such disturbances may or may not be inherited; the environment, childhood experiences, and many other factors have a bearing on the production of psychiatric disturbances.

g. **Mechanical Disturbances.** Certain static mechanical abnormalities may result in disease within the body. For example, volvulus or twisting of the intestine on itself, torsion of the spermatic cord, strangulation of a hernia, and intussusception, are all often of a purely mechanical basis.

h**. Disorders of Metabolism, Growth, or Nutrition.** Metabolism has to do with the total chemical cycle of converting substances into forms that are usable to the body. Metabolism occurs in two phases.

(1) Anabolism. In anabolism, foodstuffs are broken down (digested) and reconverted into compounds that can be utilized as energy, or as building blocks for new tissue cells and substances. In anabolism, living tissue is manufactured from nonliving substances. This results in growth or replenishment.

(2) Catabolism. Catabolism is the breaking down of the body's complex substances by wear, tear, and age into waste products of simpler composition for elimination. Metabolism and growth then are dependent on the body's receiving enough of the proper foodstuffs in order to supply its needs, in other words, on proper nutrition. Metabolism and growth are further regulated by the vitamins and hormones. The hormones are supplied by the ductless glands of the body (the pituitary, thyroid, parathyroids, pancreas, adrenals, and gonads), and any disorder of these glands will profoundly disturb growth and metabolism. The vitamins are supplied by the diet; if the diet or nutrition is unsatisfactory, disturbances in growth and metabolism can result also. Therefore, metabolism, growth, and nutrition are closely related to one another.

i. **Neoplasms (Tumors).** Normally, the body grows by multiplication of its cells. At first, in the embryo, these cells are all alike or undifferentiated, but as they multiply, they come under the influence of certain factors and take on different forms and different functions to make up the different tissues, organs, and systems of the body (that is, they become differentiated). This growth and differentiation is a slow, methodical, controlled process. However, some cells may not differentiate entirely, but for some unknown reasons, retain varying degrees of undifferentiation, break free of their growth control and form a new growth (neoplasm) or tumor. Tumors cause disease by interfering with the function of normal cells, tissues, and organs. They may cause pressure on an organ so that its normal cells are destroyed or its blood supply is shut off. A tumor may fill the cavity of an organ so that the organ wall cannot contract properly. The tumor may also use up the nutritive materials taken into the body so that there is not enough for the normal tissues. Tumors are of two types: benign and malignant.

(1) Benign. These are more slowly growing, the cells are more differentiated, the tumor is well separated from the surrounding tissues by its capsule, and can usually be completely removed surgically.

(2) Malignant. These are more rapidly growing with very little growth control, and the cells are more primitive or undifferentiated. The cells of the tumor infiltrate or grow between the normal tissue cells, and are much more difficult to remove

surgically. Because of this, the malignant tumor tends to recur and tends to metastisize or spread via the blood and lymph vessels. The common term for malignant tumors is cancer. The medical profession speaks of carcinoma when the malignant tumor arises from tissue that covers the surface of the body, lines a hollow structure, or forms glands, and sarcoma when the malignant tumor arises from any other tissue in the body such as fatty, muscular, bony, or fibrous tissue.

j. **Idiopathic (Unknown) Causes.** There are many diseases of unknown etiology. The affected organ and effective treatment are often known, however, even though the cause and the mechanism through which the disease disrupts the body's functions remain unknown.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided.

After you have completed all these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. From the definitions below, select the definition of the term anatomy.

   a. The study of the functions of the body.

   b. The study of the chemical substances in the body.

   c. The study of the structure of the body.

   d. The study of the systems of the body.

2. From the definitions below, select the definition of the term tissue.

   a. A grouping of like cells working together.

   b. The smallest living unit of body construction.

   c. A group of organs working together.

   d. A group of cells that have little in common.

3. From the functions below, select the function of the lymphatic system.

   a. Protects the body from drying.

   b. Returns protein and fluid from the various body tissues to the blood.

   c. Manufactures hormones.

   d. Provides nutrients to the arms and legs.

4. From the descriptions below, select the best description of cytoplasm.

   a. Organelles that perform highly specialized functions in the cell.

   b. A jelly–like substance that coats the outside of the cell membrane.

   c. The part of the cell that makes DNA.

   d. The fluid or semi–fluid substance contained inside the cell membrane, but outside the nucleus.

5. From the descriptions below, select the best description of mitochondria.

   a. The site of cell reproductive activity.

   b The site of cell respiratory activity.

   c. The part of the cell responsible for producing DNA.

   d. The organelle responsible for monitoring the flow of water into the cell.

6. From the groups of components listed below, select the group(s) that contain(s) the components of a Ribonucleic acid nucleotide.

   1. deoxyribose
   2. a phosphate group
   3. ribose
   4. an electron of sodium
   5. a pair of unknown molecules
   6. an organic nitrogen–containing base

   a. 1, 2, 3, and 4.

   b. 2, 3, and 4.

   c. 3, 5, and 6.

   d. 2, 3, and 6.

7. Select, from the definitions below, the definition of diffusion.

    a. The movement of solute molecules from an area of lower concentration to an area of higher concentration.

    b. The movement of solvent molecules from an area of higher concentration to an area of lower concentration.

    c. The movement of solute molecules from an area of higher concentration to an area of lower concentration.

    d. The movement of solute and solvent molecules to produce desired collisions.

8. From the definitions below, select the definition of a hypotonic solution.

    a. A solution that has a greater concentration than that of a normal cell.

    b. A solution that has a lesser concentration than that of a normal cell.

    c. A solution that has a tonicity equal to that of a 14.6chloride solution.

    d. A solution used to cause cells to shrink.

9. A normal cell has just been placed into a very hypotonic solution. From the descriptions below, select the best description of what would happen to that cell.

    a. The cell would increase in size.

    b. The cell would increase its amount of DNA.

    c. The cell would decrease in volume.

    d. The concentration of the cell's contents would increase.

10. From the group of mechanisms below, select the mechanism(s) responsible for absorption of tissue fluid.

    a. Osmosis at the venous end of the capillaries.

    b. Osmosis at the arterial end of the capillaries.

    c. Collection by the lymphatic system.

    d. a and c.

11. From the definitions below, select the definition of the term edema.

    a. A swelling of cells due to a lack of tissue fluid.

    b. A swelling of tissue due to a lack of tissue fluid.

    c. A swelling of cells that lack DNA.

    d. A swelling of tissue due to excess tissue fluid.

12. From the descriptions below, select the description of connective tissue.

    a. The tissue that binds other tissues together and supports other tissues.

    b. The tissue that lacks any specific purpose.

    c. The tissue that covers the sense organs of the body.

    d. The tissue that conducts electrical charges.

13. From the definitions below, select the definition of intercellular substance.

    a. Living material found between living cells.

    b. Nonliving material found between living cells.

    c. Living fibers found between living cells.

    d. Nonliving material found inside cells.

14. From the group below, select one of the causes of edema.

    a. Lymphatic obstruction.

    b. Sufficient colloid in the blood.

    c. Decreased permeability of blood capillary endothelium.

    d. Decreased hydrostatic pressure in blood capillaries.

15. Select, from the definitions below, the definition of the term pathology.

    a. The study of nutrition.

    b. The study of disease.

    c. The study of drugs.

    d. The study of the functions of the body.

16. From the statements below, select the statement that best describes how neoplasms can cause disease.

    a. By interfering with the function of normal cells, tissues, and organs.

    b. By producing bacterial growth.

    c. By causing the patient's temperature to greatly increase.

    d. By causing the patient's cardiac output to decrease.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1.

1. c (para 1–1a)
2. a (para 1–2b)
3. b (para 1–3f)
4. d (para 1–7e)
5. b (para 1–7g)
6. d (para 1–8b)
7. c (para 1–10)
8. b (para 1–11c)
9. a para 1–11c)
10. d (paras 1–13c(1), (2))
11. d (para 1–13d)
12. a (para 1–14c)
13. b (para 1–15a)
14. a (para 1–13d(2))
15. b (para 1–16)
16. a (para 1–17i)

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2 Anatomy and Physiology.

TEXT ASSIGNMENT Paragraphs 2−1 through 2−51.

LESSON OBJECTIVES After completing this lesson, you should be able to:

2−1. Select the statement that correctly describes the function(s) in which the blood participates.

2−2. Select the statement that correctly describes the component(s) of blood plasma.

2−3. Select the statement that correctly describes the function(s) of plasma.

2−4. Select the name of the part of the heart to which the arrow is pointing.

2−5. Select the statement that best describes the function of the valves of the heart.

2−6. Select the statement which best describes the sinoatrial (SA) node or the atrioventricular (AV) node.

2−7. Select the statement that best describes the difference between the systole and the diastolecycles of the heart.

2−8. Select the statement that best describes the function(s) of the lymphatic system.

2−9. Select the statement that correctly describes the factor(s) that influence lymph flow.

2−10. Select the statement that correctly describes the function(s) of lymphatic tissue.

2−11. Select the two protective functions of the liver.

2−12. Select the statement that best describes the omponents of bile.

2–13. Select the statement which best describes the function(s) of bile salts.

2–14. Select the statement that best describes the metabolic function(s) of the liver.

2–15. Select the statement that best describes aspecific metabolic function of the liver.

2–16. Select the statement that best describes the hematologic function(s) of the liver.

2–17. Select the statement that best describes the cause for a particular type of jaundice.

2–18. Select the correct name of the part of the digestive system to which the arrow is pointing.

2–19. Select the statement that best describes the function(s) of saliva.

2–20. Select the statement that best describes the function(s) of a type of cell located in the gastric glands of the stomach.

2–21. Select the statement that best describes the function(s) of a specific pancreatic enzyme.

2–22. Select the statement that best describes the end product of the digestion of one of the following substances: carbohydrates, proteins, or fats.

2–23. Select the statement that best describes the substances absorbed in a specific part of the digestive system.

2–24. Select the statement that best describes the functional unit of the kidney.

2–25. Select the statement that best describes the function(s) of the nasal cavity.

2–26. Select the statement which best describes a particular part of the respiratory system.

2-27. Select the best description of a particular type of lung volume associated with breathing.

2-28. Select the statement that best describes the process of gas exchange in the lungs.

2-29. Select the statement that best describes how the majority of oxygen is transported in the body.

2-30. Select the method by which most of the carbon dioxide is transported in the plasma.

2-31. Select the statement that best describes the division(s) of the nervous system.

2-32. Select the statement that correctly describes the components of the central nervous system.

2-33. Select the best description of a part of the central nervous system.

2-34. Select the statement that best describes the function(s) of the cerebrospinal fluid (CSF).

2-35. Select the statement that best describes the definition of the term meningitis.

2-36. Select the statement that best describes the divisions of the autonomic nervous system.

2-37. Select a particular action that categorizes it as belonging to either the sympathetic orparasympathetic part of the autonomic nervous system.

2-38. Select the best description of a particularendocrine gland.

2-39. Select the statement that best describes the function of a hormone produced by an endocrine gland.

SUGGESTION

After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

ANATOMY AND PHYSIOLOGY

Section I. THE CIRCULATORY SYSTEM AND THE LYMPHATIC SYSTEM

2−1. NEED FOR A CIRCULATORY SYSTEM

a. **Unicellular Animals.** In primitive animals which are composed of one, or only a very few cells, there is no need for a circulatory system. All of the cells are exposed to the environment (energy source and waste removal) and are equally capable of carrying on the processes, which are necessary to sustain life. No cell is dependent on any other cell to any great extent, and no circulatory system is necessary for survival.

b. **Complex Organisms.** Unlike the simple one−celled organisms, the human being has many specialized cells. Most of these cells are not exposed to the environment. Therefore, they are unable to obtain the materials needed for life or to remove their waste products on their own. The circulatory system serves to meet the needs of the cells of the body. Food, water, oxygen, and all the other substances required by the cells are delivered by the circulatory system. Likewise, the waste products of the cells are removed by the circulatory system. The general composition of the bloodstream remains very uniform, despite the fact that chemical substances and cellular elements are continually leaving and entering the bloodstream.

2−2. BASIC FUNCTIONS OF THE CIRCULATORY SYSTEM AND BLOOD

Because blood flows through every organ in the body, blood participates in every major function of the body.

a. **Respiration.** Blood carries oxygen from the lungs to all parts of the body. The oxygen capacity of the blood depends directly on the hemoglobin concentration.

b. **Nutrition.** Through the bloodstream, food materials are absorbed from the digestive tract and carried to the tissue cells all over the body. Such absorbed food products may be used immediately by active cells or stored. If nutritional materials are stored, they may be used at any time by being transported by the blood when the need arises.

c. **Excretion.** In respiration, the blood carries carbon dioxide from the tissues to the lungs. The blood also carries waste products for elimination by the excretory organs.

d. **Acid−Base Balance.** The blood has certain buffer systems so that neither a too acid nor a too alkaline condition occurs. The buffers in the blood include the protein, bicarbonate, and phosphate buffers. If CO_2 were not removed by the lungs and neutralized by the bicarbonate buffer system, the blood would rapidly become too acid. The buffer systems of the blood are so sensitive that the blood pH is held at an almost constant level of about 7.40.

e. **Water Balance.** The maintenance of normal fluid distribution and water balance in the body depends on the mobility of the water found in the blood. The osmotic pressure of the plasma proteins is of great physiologic importance in the regulation of the movements of fluid between the capillaries and the tissue spaces.

f. **Regulation of Body Temperature.** Mammalian tissue can function with maximal efficiency only within closely restricted limits of body temperature. The metabolic processes, which occur during cell activity are constantly producing heat. Since blood passes through the capillaries of all organs, it tends to redistribute the heat produced in these areas. The circulation of blood in the vessels of the skin and lungs permits heat to be lost from the body by radiation and evaporation.

g. **Regulation of Hormone Transport.** The effectiveness of hormones is entirely dependent on the circulation of blood. The transport to the tissues of various hormones of the glands is carried out entirely by the blood.

NOTE: The formed elements of blood and the phenomenon of coagulation are discussed in detail in Subcourse MD0853, Hematology. Therefore, no review is given here.

2−3. BLOOD PLASMA

a. **Composition.** Plasma is the fluid part of blood obtained by separating the formed elements from whole blood. Plasma is a clear, straw colored liquid that contains a large number of substances in solution. Plasma makes up about 55 percent of whole blood. Plasma is about 91.5 percent water and 7 percent protein (albumins, globulins, fibrinogen, and prothrombin). The remainder includes inorganic salts, lipids, enzymes, hormones, vitamins, and carbohydrates.

b. **Functions of Plasma.**

(1) Suspension medium. Since plasma comprises 55 one of the functions of plasma is to act as a suspension medium for the formed elements. Blood cells are kept suspended and circulating in a bath of plasma. Plasma also keeps the proper volume of fluid circulating throughout the body.

(2) Coagulation. The factors for the process of coagulation, which is characteristic of blood, are contained chiefly within the plasma fraction of the blood. Platelets, of course, contribute to the clotting mechanism. It is the plasma protein, fibrinogen, however, which is the soluble precursor of the jelly−like fibrin in a blood clot.

(3) Transport. Blood functions as the chief means of transport for materials within the body. Since most substances are not absorbed by the formed elements, it is the plasma that functions as a solvent for most materials transported by the blood to the capillaries in all parts of the body.

(4) Antibodies. While antigens are frequently carried on the surface of red cells, antibodies, both natural and acquired, are transported by the plasma portion of the blood.

(5) Blood volume. The maintenance of a proper blood volume is one of the functions of plasma, the fluid portion of blood. Plasma must be at a high enough level to fill the chambers of the heart in the pumping mechanism. The plasma portion must not exceed an optimum level, or the heart will be unable to handle the excess fluid and thus will become water-logged.

(6) Gases. About 60 carried in the form of bicarbonate (HCO_3). Small fractions of oxygen and carbon dioxide are carried as gases dissolved in the plasma.

(7) Waste. Waste products from cellular metabolism are carried away by the plasma portion of the blood, as well as the lymphatic system.

(8) Nutrients. The nutrients that nourish the cells and provide them with substances necessary for life are carried in the plasma portion of blood. These products are carried from the point of manufacture to the capillaries and on to the individual cells.

(9) Hormones. Hormones are carried exclusively by the plasma of the bloodstream to the different tissues. Blood is the only means of transport for hormones.

2-4. GENERAL DESCRIPTION OF THE CIRCULATORY SYSTEM (Figure 2-1)

a. **Heart.** The heart is a hollow, muscular organ situated in the thorax, and extending approximately from the third rib to just about the sixth rib, and with about two-thirds of its mass to the left of the midline. The heart is the pumping unit whereby blood is circulated throughout the body (figure 2-1). The heart is enclosed in a double-walled fibroserous sac called the pericardium. The pericardial fluid lubricates the pericardium and prevents friction during movement of the heart.

b. **Blood Vessels.** The blood vessels are composed of arteries (figure 2-2), veins (figure 2-3), and capillaries. Arteries are the vessels that convey the blood away from the pumping chambers of the heart. Veins have thinner walls than arteries and are the vessels that return blood to the pumping chambers of the heart. Capillaries, the smallest vessels, provide the means for exchanges between the blood and tissues. Capillaries form a network in the tissues and are characterized by a very thin wall.

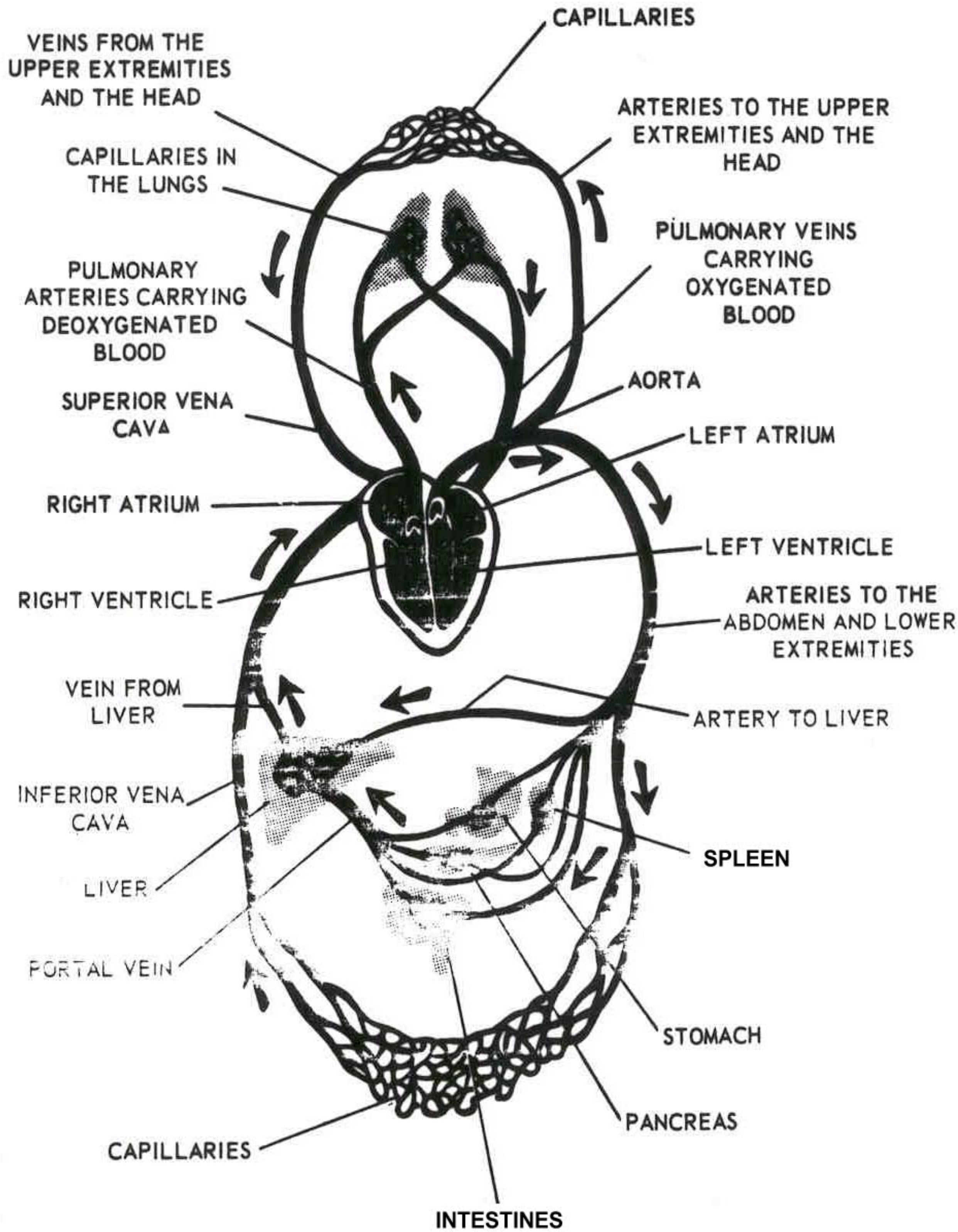


Figure 2-1. Diagram of the cardiovascular system.

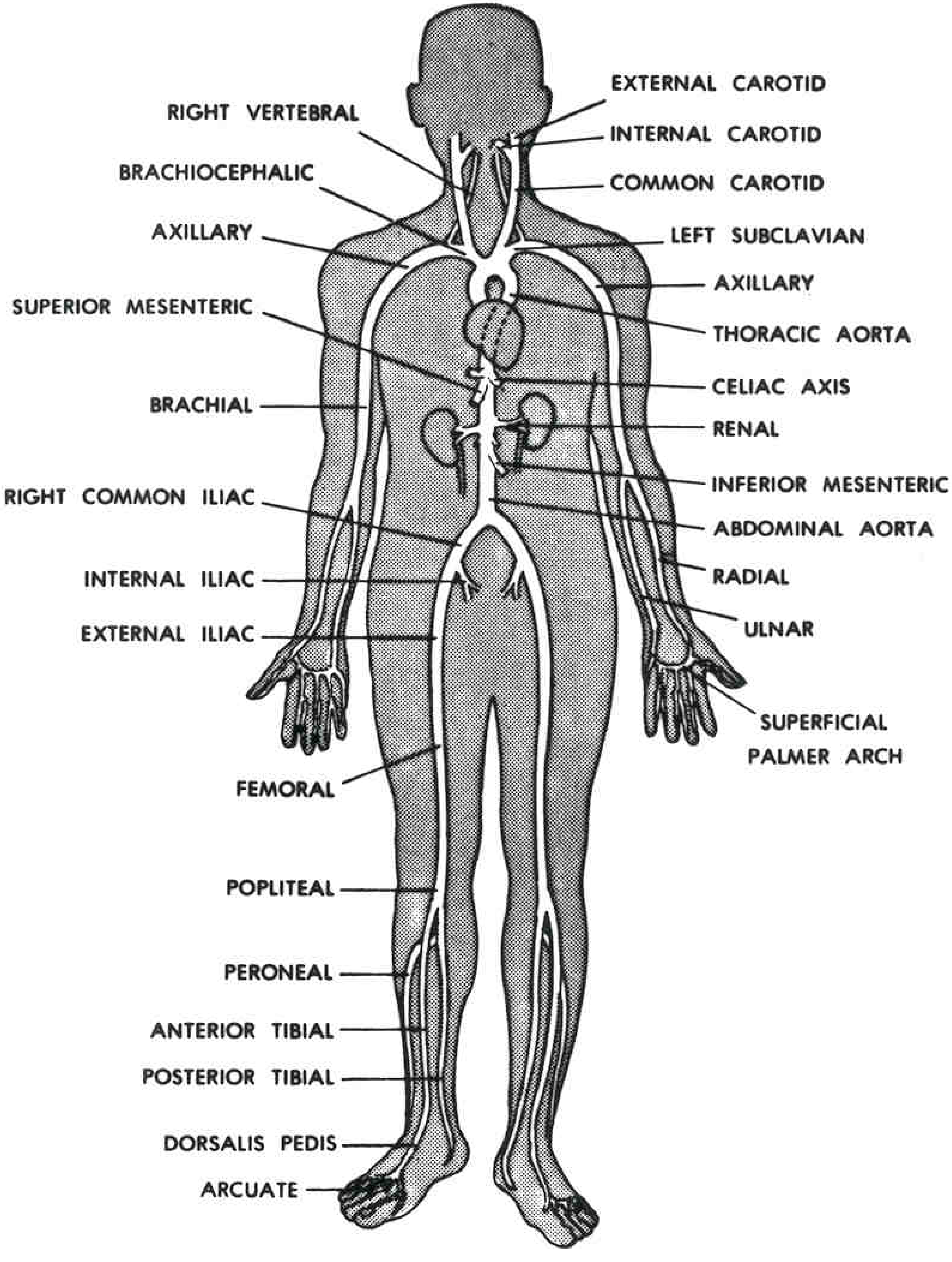


Figure 2-2. Principal arteries.

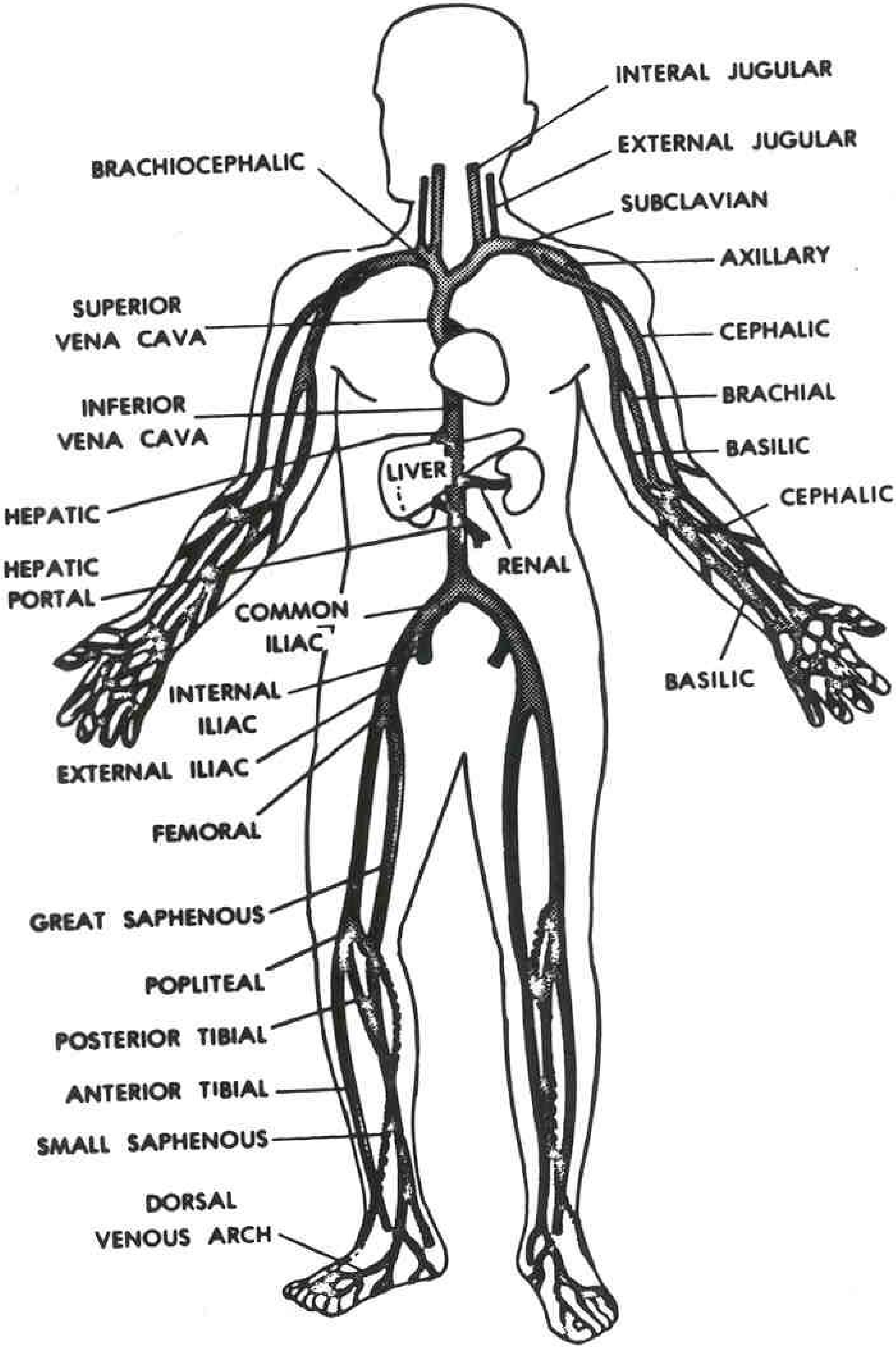


Figure 2-3. Principal veins.

c. **Function.** The function of the heart and the blood vessels is to keep the blood circulating throughout the body. The heart provides the pumping mechanism and the vessels provide the system through which the blood flows. The human body cannot live if the heart or the vessels stop functioning.

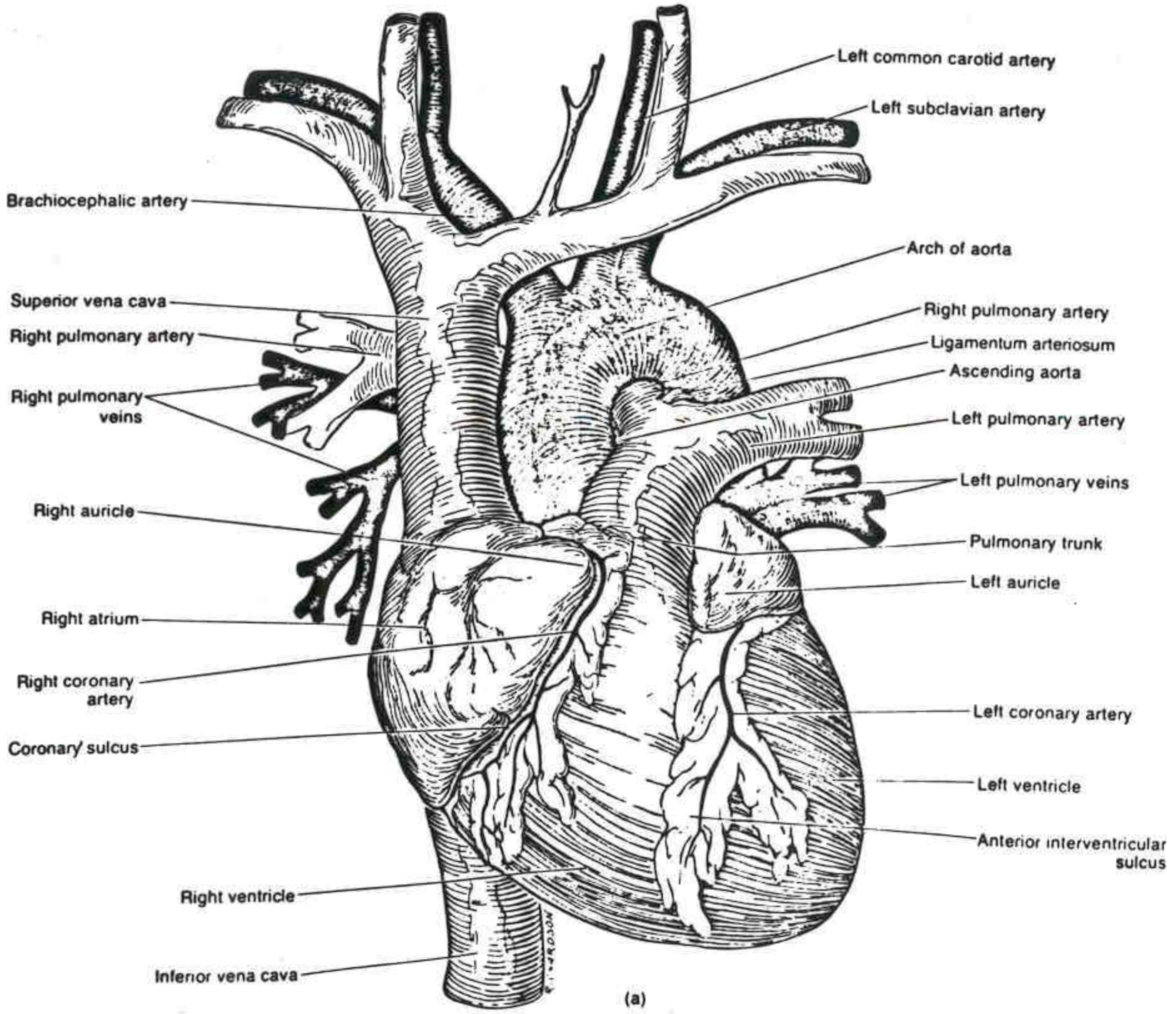
d. **Functional Unit of Closed Tubes.** The heart and vessels of the circulatory system provide an essentially closed unit within the body. The same amount of blood that is pumped out of the heart must return to the heart. In the arteries, blood flows away from the heart. The large arteries lead into smaller arteries called arterioles. From the arterioles blood passes into capillaries, which return blood to the heart by means of small veins called venules and then larger veins. (One of the lymphatic system's primary functions is to return proteins and other substances, which have escaped from the capillaries back into the veins.)

2−5. THE HEART

a. **Three Layers.** The heart (figure 2−4) has three layers: a thin, outer, serous covering called the epicardium; a thick, muscular wall, the myocardium; and an inner lining, the endocardium, which is continuous with the lining (endothelium) of the blood vessels.

b**. Four Chambers.** The interior of the heart is divided into halves by a muscular wall, the septum; and each half is further divided into an upper chamber, the atrium; and a lower chamber, the ventricle. Consequently, there are four chambers in the heart; two atria and two ventricles. Each atrium communicates with its corresponding ventricle (that is, the one on the same side) by means of an opening called the atrioventricular opening. The muscular walls of the ventricles are much thicker than those of the atria, and the wall of the left ventricle is thicker than that of the right ventricle. This difference in structure is due to the fact, that the ventricles, which eject the blood from the heart, perform more work than the atria, which receive the blood. The left ventricle pumping blood to the body performs more work than does the right ventricle, which pumps blood only to the lungs.

c**. Valves.** The four chambers of the heart are lined with endocardium. At each of the openings from the chambers, this lining folds on itself and extends into the opening to form valves. These valves allow the blood to pass from a chamber but prevent its return. The tricuspid valve lies between the right atrium and ventricle. It has three flaps, or cusps, from which it derives its name. The bicuspid valve, between the left atrium and ventricle, is also called the mitral valve. These two valves serve to prevent the backflow of blood from the ventricles to the atria. At the outlets of the ventricles are the semilunar valves, which prevent the backflow of blood from the arteries. The semilunar valve on the right is called the pulmonary valve; the one on the left is the aortic valve.



Structure of the heart. (a) Anterior external view.

Figure 2-4. The heart.

d. **Blood Supply.** Blood from the upper part of the body enters the right atrium by way of a large vein, the superior vena cava, and from the lower part of the body by the inferior vena cava. When the right atrium becomes filled, it contracts, and blood is forced through the open tricuspid valve into the right ventricle.

e. **Heart Regulation.**

(1) The sinoatrial node. The sinoatrial (SA) node is a small, specialized tissue located in the posterior of the right atrium between the opening of the superior vena cava and the coronary sinus. The SA node is the pacemaker of the heart. Under normal conditions, it produces the impulses that determine the heartbeat.

(2) The atrioventricular node. In the lower part of the inner wall of the right atrium and above the valves opening into the right ventricle, there is a special tissue called the atrioventricular (AV) node. This node also functions in contracting the heart. The AV node acts as a relay station for the impulses originated by the SA node.

f. **Cardiac Cycle.** The action of the heart occurs as a cycle, repeated continuously and in regular rate and rhythm. The cycle consists of alternate contraction and relaxation of the heart, the wave of contraction beginning in the atria and spreading to the ventricles. This phase of contraction is known as systole; that of relaxation is called diastole. Several actions occur simultaneously during each phase. During the systolic phase, both atria contract at the same time, followed in an instant by the simultaneous contraction of the ventricles. At the beginning of ventricular contraction, the tricuspid and bicuspid valves close; at the end of ventricular contraction, the aortic and pulmonary semilunar valves close. Immediately upon closure of the semilunar valves, the diastolic phase, or rest period, begins. During this phase, the atria and then the ventricles relax as blood flows into the atria and ventricles. As the atria become filled, the AV valves open, the atria contract, and the systolic phase begins again.

2−6. THE LYMPHATIC SYSTEM

a. **Functions.**

(1) Immunity. The lymphatic system (figure 2−5) plays an important role in immunity. The lymph nodes, which are small, oval bodies of lymphoid tissue occurring at strategic places along the course of lymph vessels, are a line of defense against different types of foreign matter, whether of living organisms or inert particles. These particles are carried by the lymph to the lymph nodes where they come into contact with lymphatic phagocytes. These phagocytes prevent many foreign materials from entering the bloodstream. Inert particles accumulate in the lymph nodes and will finally cause a type of fibrous proliferation. If the particles entering the lymphatics happen to be particularly pathogenic bacteria, they may overcome the lymphatic barrier, pass into the bloodstream, and cause a general sepsis.

(2) Intestinal absorption. The lymphatic system is one of the major channels for absorption from the intestinal tract. Fats of more than 12 carbon atoms are absorbed through the intestinal villi into lymphatic vessels called central lacteals; smaller fats are absorbed directly into the bloodstream. Fats in the lymphatic system pass through the thoracic duct to the bloodstream. During digestion, the lymph in the lacteals is milky in appearance and is called chyle. Chyle contains the fats absorbed from the intestine. After a fatty meal, the lymph in the thoracic duct may contain as much as two percent fat.

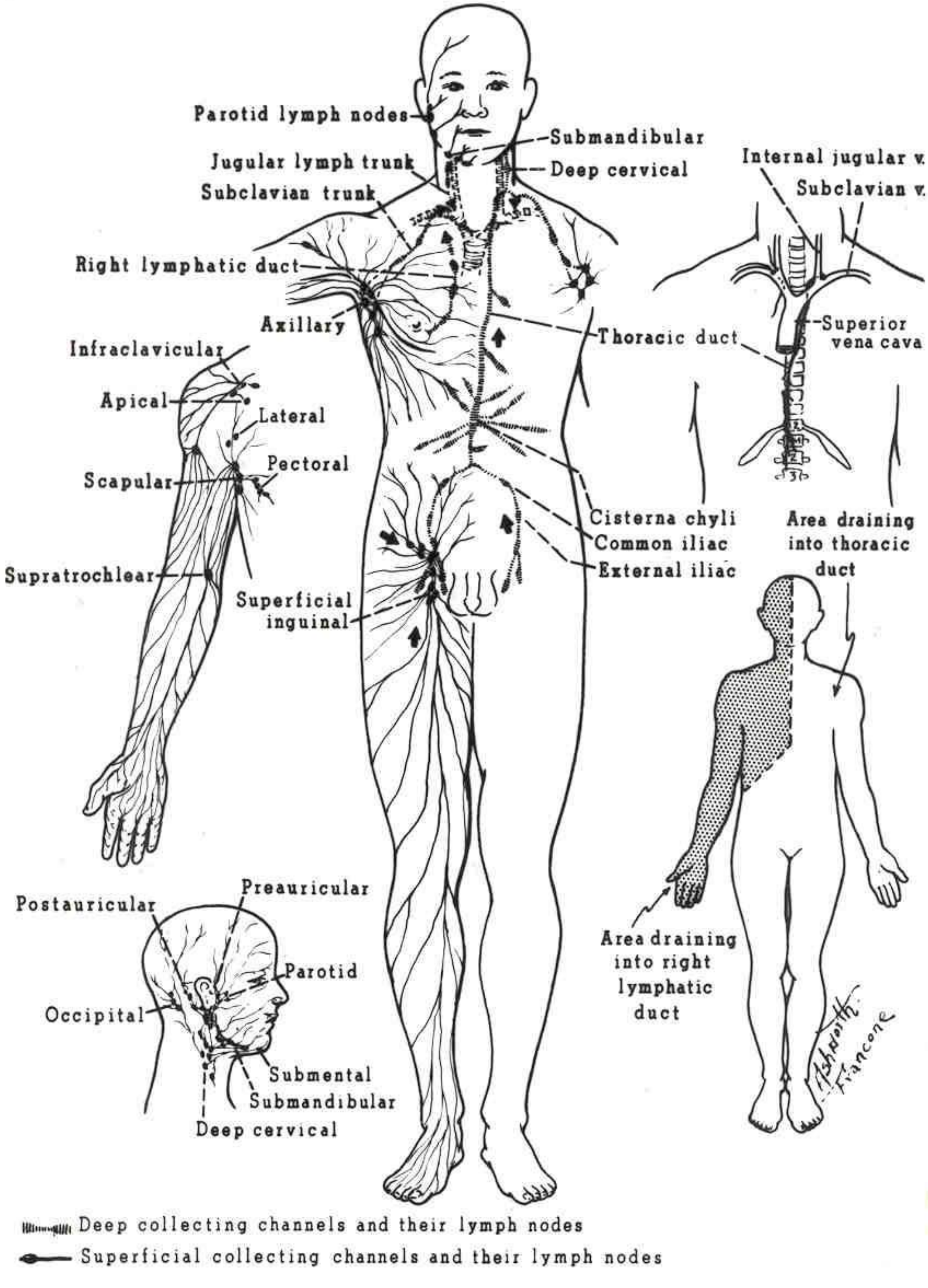


Figure 2-5. The lymphatic system and drainage.

(3) Formation of lymphocytes. The lymphatic system is one of the main sources for the manufacture of lymphocytes. Lymphocytes are almost the only cells found in lymph. Occasionally monocytes are seen. Lymphocytes are a type of white blood cell formed in the lymph nodes and other structures of the lymphatic system. The number of lymphocytes found in the lymph varies with the time and the location. Between 2,000 and 20,000 lymphocytes per microliter have been found in the lymph of man (1 microliter = 1 cubic millimeter = 0.001 mL).

(4) Draining the tissue spaces. The lymphatic system provides an accessory route by which fluids can travel from the interstitial spaces into the blood. The lymphatics can carry proteins and even larger particulate matter away from the tissue spaces. Neither can be removed by direct reabsorption into a blood capillary. The removal of proteins from the tissue spaces is an absolutely essential function performed by the lymphatic system.

b. **Anatomical Distribution.** Very small lymphatic vessels originate in the intercellular spaces. They have endothelial walls that are extremely thin and very permeable to fluid from the tissues. Their contents are not in direct contact with the cells, nor do they mix with the tissue fluids.

c. **Formation of Lymph.** Lymph is formed by the filtration of tissue fluid into the smallest lymphatic vessels. Lymph is formed from the excess of tissue fluid not reabsorbed by the capillaries of the blood. In some tissues such as the intestinal tract, liver, and heart, lymph formation is almost continuous. In some other tissues the formation of lymph may be quite considerable only at certain times. The amount of lymph formed varies with different parts of the body at different times. Lymph, therefore, originates as interstitial fluid that filters from the blood capillaries through the tissues into the lymphatics.

d. **Composition and Properties.** The chemical composition of lymph may vary considerably from one lymphatic area to another. Lymph in the right lymphatic duct varies considerably from lymph in the thoracic duct; lymph in the thoracic duct is high in fat content due to the large amount of fat absorbed into the lymph in the area of the small intestine. Except for its lower protein concentration, lymph is composed of a watery solution of the same substances as those of blood plasma. The only cell normally found in lymph is the lymphocyte, which is manufactured in the lymphatics.

e. **Factors That Influence Lymph Flow.**

(1) Valves. As mentioned previously, the lymphatic vessels have valves like those of the veins that prevent lymph from flowing backward. Lymphatic flow is largely due to external pressure variations, resulting from arterial pulsations, skeletal muscle contractions, and respiration. The presence of many valves in the lymphatic vessels ensures that the lymph always moves in the correct direction.

(2) Smooth muscle. The walls of the larger lymphatic vessels include smooth muscle fibers that aid in lymph flow.

(3) Negative thoracic pressure. Negative intrathoracic pressure is due to the elastic recoil of the lungs. It exerts a continual aspiratory effect on the lymphatic system in the same manner as on the venous system.

(4) Skeletal muscle contraction. Contraction of the skeletal muscles has the same effect on the lymphatic system as it does on the venous system. This works in the same manner because of the flaccidity of the walls of the lymphatics, and because of the existence of valves.

(5) Pulsating arteries. The pulsating of arteries close to the lymphatics also increases lymphatic flow.

(6) Gravity. Gravity either speeds up or slows down the flow of lymph. If the lymphatic territory is above its opening into a vein, the flow is speeded up by gravity. If the lymphatic territory is below its opening into a vein, gravity retards the flow of lymph.

f. **Lymphatic Tissue.**

(1) Functions.

(a) Return of vital substances, especially proteins, to the blood vessels.

(b) Formation of lymphocytes.

(c) Detoxification of foreign molecules and particles.

(d) Antibody production.

(e) Prevention of edema by constant removal of excess fluid from tissue spaces.

(2) Structure (figure 2-6).

(a) Afferent lymphatics. Lymph enters a node by way of the afferent lymphatics which are situated around the periphery of the node.

(b) Efferent lymphatics. Lymph leaves a lymph node by way of the efferent lymphatics which lead to veins.

(c) Capsule. The outer covering of a lymph node is referred to as a capsule.

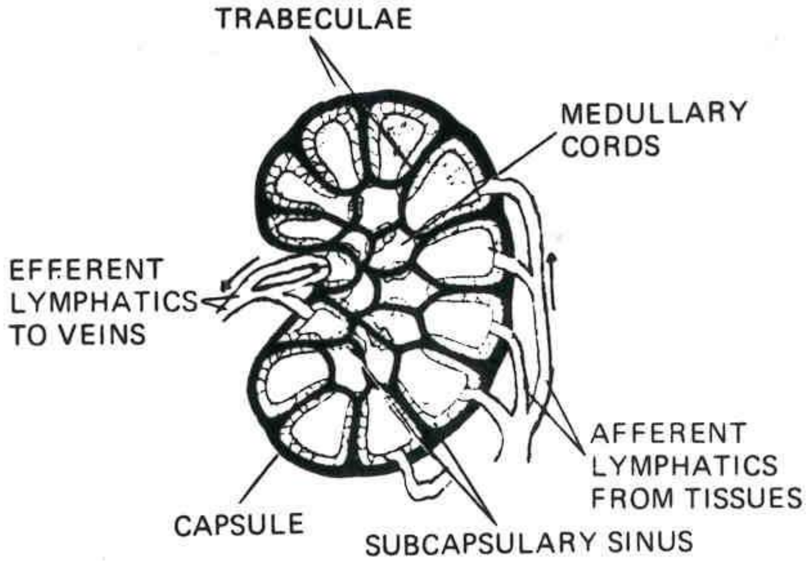


Figure 2-6. Lymph node.

(d) Medullary cords. Once inside the lymph node, the lymph must wind its way along the medullary cords of sinuses. These sinuses are lined by reticulum cells that are capable of ingesting foreign material. This removes unwanted materials before they can be emptied into the blood.

Section II. THE LIVER

2-7. INTRODUCTION

When the liver malfunctions, it will ultimately affect metabolic processes occurring throughout the body. In turn, the materials or products resulting from an abnormal liver will directly or indirectly affect body fluids analyzed in the medical laboratory. A knowledge of the liver should provide some understanding of what changes can occur in samples analyzed in the laboratory.

a. **Position.** The liver, located in the upper right quadrant of the abdominal cavity, is juxtapositioned (beside) to the inferior surface of the diaphragm.

b. **Structure.** The liver is composed of four lobes: the right, left, caudate, and quadrate lobes. The right and left lobes are the largest lobes of the liver. A conspicuous external duct system emerges from the inferior side of the liver. A right and left hepatic duct depart from the right and left lobes respectively. The two ducts then fuse forming a common hepatic duct. The common hepatic duct joins the cystic duct from the gallbladder and beyond this junction the duct is termed the common bile duct. The common bile duct then connects with the duodenum. At the base of the bile duct is a sphincter, which controls the flow of bile from the liver and gallbladder into the small intestine. The sphincter, called the sphincter ampulla, can therefore remain constricted and store bile until it is needed within the digestive tract.

2−8. CIRCULATION

The liver has three major blood vessels, two of which lead into the structure and one departs from it. The former vessels are the <u>hepatic portal vein</u> and the <u>hepatic artery</u>. The hepatic artery is a branch of the aorta that functions to bring oxygenated blood to the liver. It branches to arterioles and eventually into sinusoids (capillaries) within the liver. From the sinusoids, blood flows to the central vein to sublobular veins and departs from the liver via the hepatic vein. The second large blood vessel entering the liver is the hepatic portal vein (figure 2−7), which receives blood rich in nutrients from the digestive tract. This vein enters the liver and divides into portal venules, which subdivide to sinusoids. From the sinusoids, blood from the hepatic portal vein follows similar channels as blood from the hepatic artery. That is, blood flows from a sinusoid to a central vein, to a sublobular vein, and to the hepatic vein. The hepatic vein therefore receives blood from the hepatic artery and portal veins and returns the blood to the heart via the inferior vena cava. The enriched blood is oxygenated prior to being distributed to vital organs and tissues of the body.

2-9. MICROSCOPIC ANATOMY

The microscopic anatomy of the liver ncludes the functional unit of the liver, the iiver lobule (figure 2−8). A typical liver lobule consists of hepatic cellular plates, usually two cells thick. Blood vessels found in the liver lobule include a portal venule, a venous sinusoid, and a central vein. Lining the venous sinusoids are Kupffer's cells. Kupffer's cells are very mobile and can enter and leave the bloodstream. Between the parenchymal (functional) cells are tiny vessels called bile canaliculi. Many canaliculi fuse forming larger and larger bile ducts. The contents of these ducts leave the liver via the left and right hepatic ducts.

2−10. PROTECTIVE FUNCTIONS

a. Kupffer's Cell Activity. Blood entering the liver through the portal system from the intestines, contains large numbers of colon bacilli. The Kupffer's cells in the liver remove successfully over 99 percent of these bacteria. The Kupffer's cells act as a very efficient filter for bacteria or any other particles in this size range from the blood. Without the activity of the Kupffer's cells, bacteria would be allowed to enter the entire systemic circulation and a generalized septicemia would result.

b. **Ammonia Removal.** Large amounts of ammonia are formed during deamination in protein metabolism. The liver produces large amounts of urea from ammonia to remove it from body fluids. If the liver did not function in the secretion of urea, the plasma ammonia concentration would rise so high that very shortly the result would be hepatic failure and death would occur.

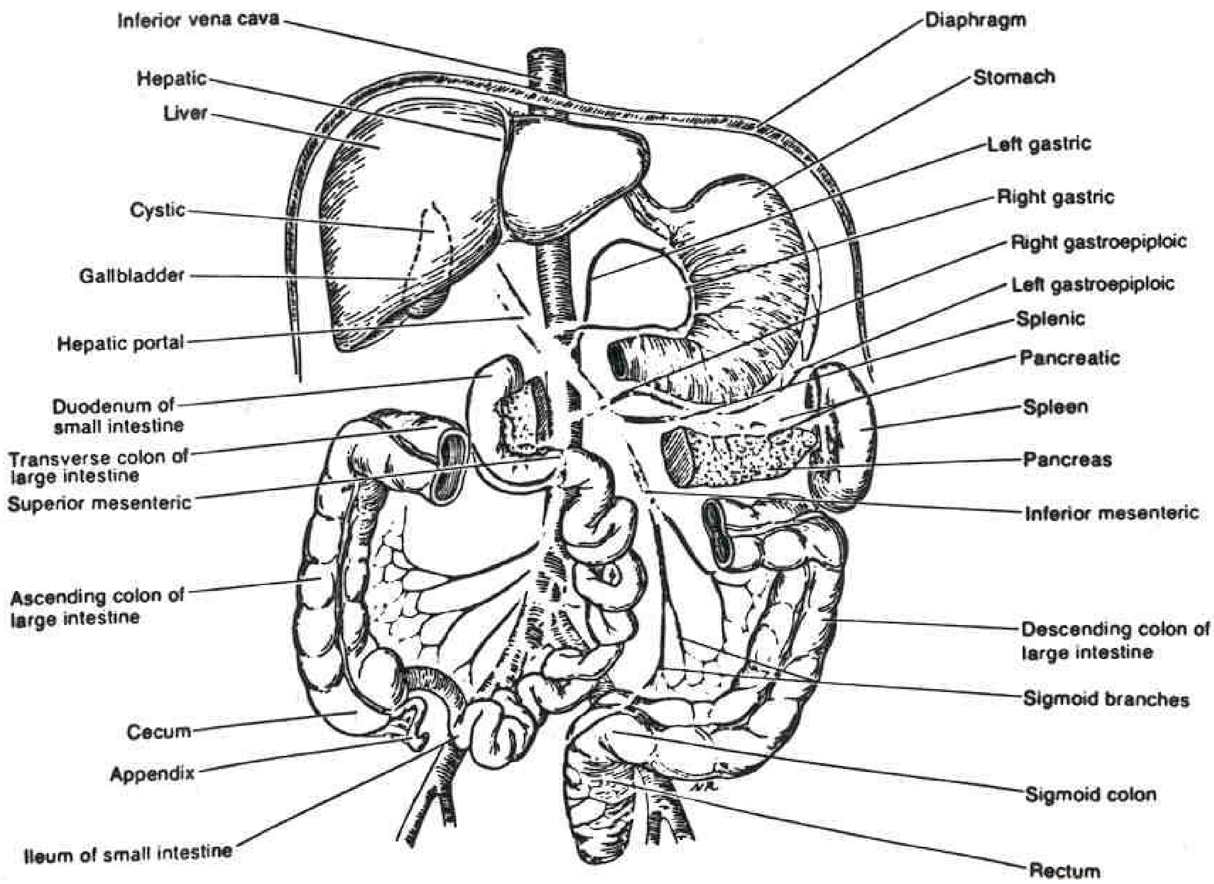


Figure 2-7. Portal circulation.

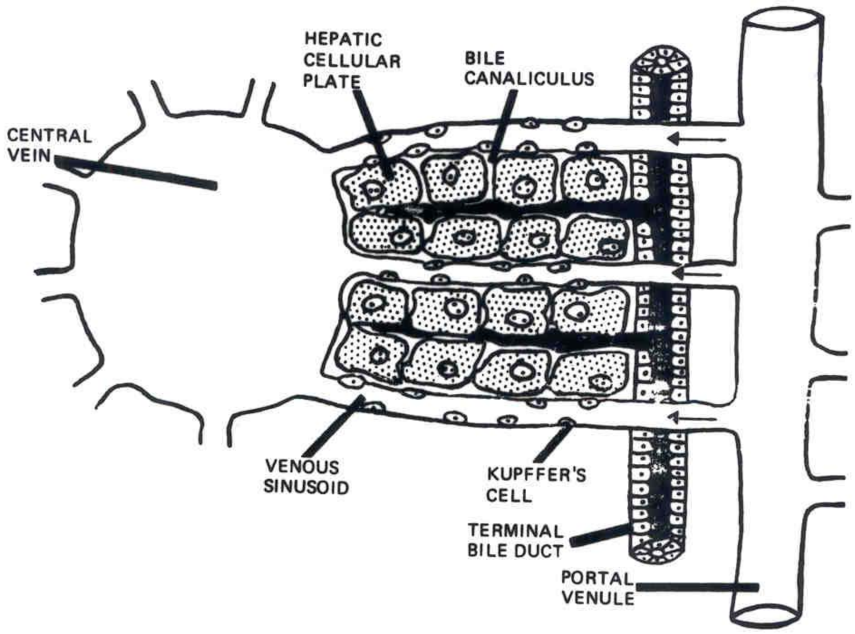


Figure 2-8. The liver lobule.

2–11. SECRETION OF BILE

Some cells in the liver secrete a substance known as bile. Bile contains large quantities of bile salts, a moderate amount of cholesterol, and a small amount of bilirubin. Bile is secreted into very small bile canaliculi (vessels), which empty into terminal bile ducts. The bile ducts become progressively larger and finally reach the hepatic duct and the common bile duct. From these ducts, bile is either emptied into the duodenum or directed to the gallbladder. A brief discussion of the three components of bile is presented below:

a. **Bile Salts.** Liver cells are constantly forming bile salts. These bile salts are obtained from cholic acid, a substance similar in structure to cholesterol. Bile salts serve two main functions in the intestinal tract.

(1) <u>Emulsifying function</u>. Bile salts decrease the surface tension of fatty particles in food and allow them to be broken up into minute fat globules by the agitation of the intestinal tract.

(2) <u>Hydrotropic function</u>. Bile salts help in the absorption of fatty acids and monoglycerides from the intestinal tract through a process known as hydrotropic action.

b. **Cholesterol.** Excess cholesterol is excreted by the liver in the bile. In some people, the cholesterol may precipitate to form gallstones in the gallbladder.

c. **Bilirubin.** Bilirubin is excreted from the liver. When red blood cells have completed their life spans (approximately 125 days) they rupture and release their hemoglobin. The body removes the iron from the hemoglobin, which changes and becomes bilirubin. However, bilirubin is insoluble in the body fluids. Bilirubin, therefore, is bound to protein in the plasma and is absorbed by the liver in this form.

2–12. METABOLIC FUNCTIONS

a. **Carbohydrate Metabolism.** Most of the liver functions in carbohydrate metabolism are concerned with maintaining a normal blood glucose level.

(1) <u>Storage of glycogen</u>. The liver is capable of taking excess glucose from the blood and storing it in the liver cells in case blood glucose level should fall. This process is glycogenesis. This is known as the glucose buffering function of the liver. In an individual with a malfunctioning liver, the blood glucose level will rise as much as three times higher after a meal high in carbohydrates.

(2) <u>Glycogenolysis</u>. Glycogenolysis (breakdown of glycogen to glucose) begins to occur when the blood glucose level falls below the normal level. In cases where the blood glucose drops significantly below the normal level, the liver is able to convert amino acids into glucose (this is called gluconeogenesis).

(3) Conversion of galactose and fructose. The liver is capable of converting galactose and fructose to glucose. This is an important function, as the greater proportion of the glucose that is formed by this method is usually released to the blood by the liver and almost no other cells in the body can convert galactose to glucose.

b. **Protein Metabolism.** Protein metabolism is the most important metabolic function carried on by the liver. If protein metabolism were to cease functioning, death would occur within 48 hours.

(1) Deamination (breakdown) of amino acids. The deamination of amino acids is necessary before they can be utilized either for energy or for conversion into fats or carbohydrates. A very small amount of deamination occurs in the kidneys but it is almost negligible. Almost all deamination required by the body is carried out by the liver.

(2) Formation of urea for the removal of ammonia from body fluids. Large amounts of ammonia are formed in the process of deamination. Without the formation of urea by the liver for the removal of ammonia, the plasma ammonia concentration would rise very rapidly and the result would be hepatic coma and death.

(3) Formation of plasma proteins. With the exception of part of the gamma globulins, almost all of the plasma proteins are formed by the hepatic cells. Over 95 percent of the plasma proteins are produced by the liver. Plasma proteins can be formed by the liver at a maximum rate of 50 to 100 grams per day.

c. **Lipid Metabolism.** Although fat (lipid) metabolism can take place in almost all the cells in the body, it occurs so much more rapidly in the live. More than 60 percent of all fat metabolism occurs in the liver.

d. **Vitamin Metabolism.** The liver has the ability to store vitamins and to store some of them in extremely large quantities. The vitamin stored in the largest quantity in the liver is vitamin A. Sufficient amounts of vitamin A can be stored in the liver to prevent a vitamin A deficiency for one or two years. Large quantities of vitamin D and vitamin B_{12} are also stored in the liver.

2–13. HEMATOLOGIC FUNCTIONS

a. **Fetal Blood Formation.** During the third through the fifth month of embryonic life, the liver forms most of the red blood cells and is, therefore, the principal organ of erythropoiesis (red blood cell production). The liver begins to acquire this function in the second month of fetal life and is totally functional by the third month. From the third through the fifth month the liver produces nonnucleated red blood cells which are of normal size. During the last three months of fetal life, red blood cells are formed almost entirely by the bone marrow.

b. **Formation of Clotting Factors.** The liver produces a large proportion of the blood clotting factors, including fibrinogen, prothrombin, and several others.

c. **Erythrocyte Destruction.** When red blood cells become old and worn out in the circulatory system, most of them are phagocytized in the bone marrow, the spleen, and the liver. The bilirubin that is formed by all of these organs is excreted by the parenchymal cells of the liver into the bile canaliculi and on through the bile ducts into the intestines. Bilirubin from the spleen and bone marrow is carried by the bloodstream to the liver sinusoids. The bilirubin diffuses through the walls of the liver sinusoids to enter the parenchymal cells.

2−14. BILE PIGMENT METABOLISM

a. **Hemoglobin Breakdown.** When red blood cells break down, hemoglobin is immediately released into the plasma.

b. **Jaundice.** Any failure of the liver to excrete bile causes an increased quantity of bilirubin to be excreted into the body fluids. These fluids containing an increased amount of bilirubin produce a yellow color in the skin, which is known as jaundice. Jaundice can also occur if, due to disease, an abnormally large amount of bile pigment is produced. The excessive amount of pigment causes the body fluids to become pigmented as well as the bile itself.

(1) <u>Hemolytic</u>. A type of jaundice known as hemolytic jaundice occurs when the reticuloendothelial cells of the body phagocytize and destroy the red blood cells so rapidly that the parenchymal cells of the liver cannot excrete all of the bile in an effective manner. This occurs most frequently when the red blood cells are imperfect due to the existence of a pathological condition in the body.

(2) <u>Obstructive</u>. Jaundice may occur if the bile ducts become obstructed so that the pigment excreted by the parenchymal cells cannot reach the intestine. In this type of case, bile is absorbed into the lymph and blood capillaries.

Section III. THE GASTROINTESTINAL SYSTEM (Figure 2−9)

2−15. DIGESTION IN THE MOUTH

Digestion is the splitting of large chemical compounds into simpler substances that can be used by the body.

a. **Ptyalin (Salivary Amylase).** Ptyalin is an enzyme found in the saliva that has the same properties as amylase. Ptyalin converts cooked starch into maltose. Most starches that man ingests must be cooked, because plant cells are surrounded by an envelope of cellulose that is indigestible for man. Since food normally stays in the

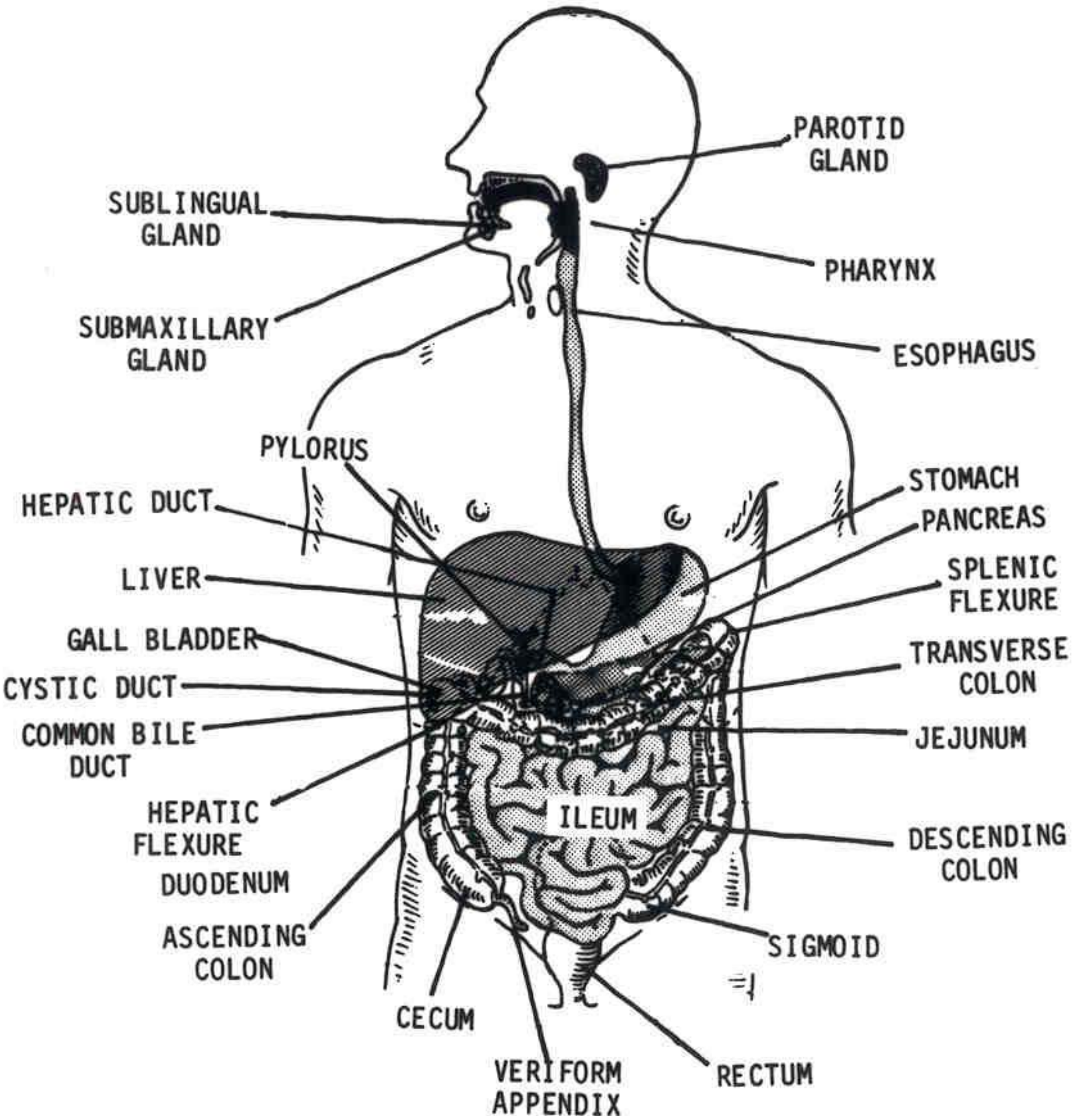


Figure 2-9. Digestive system.

mouth only a very short time, ptyalin does not usually have the chance to break food particles down. Even if starch is broken down as far as maltose in the mouth, maltose cannot be absorbed by the body in that form and must wait to be further digested by the juices of the small intestine. The enzyme ptyalin acts on starch by the process known as hydrolysis. Probably only 3 percent to 5 percent of the starch in the mouth is ever hydrolyzed into maltose. Proper chewing of food greatly aids all of the digestive processes.

b. **Lubrication.** Although the saliva that is formed in the mouth does produce the enzyme ptyalin that aids in digestion, saliva functions as a more valuable aid in other ways. Saliva is of great importance as a lubricant. Saliva moistens the food and makes it easy to swallow. Without saliva or some other liquid, it would be impossible to swallow food. Saliva lubricates and keeps the mouth soft; this plays a very important role in the mechanics of speech.

2−16. DIGESTION IN THE STOMACH

The three major functions of the stomach are to store food, mix it with gastric secretion until chyme (semifluid substance) is formed, and to slowly release the chyme into the small intestine at a rate suitable for digestion and absorption in the small intestine. The stomach plays only a small part in the actual breakdown of food into simpler substances. The following types of cells are located in the gastric glands found in the stomach's mucous coat, a membrane forming its inner lining.

a. **Parietal Cells.** Parietal cells are the cells that secrete hydrochloric (HCl) acid into the stomach. Gastric juice contains between 0.4 and 0.5 percent hydrochloric acid. (The stomach wall is not digested by this acid because it is coated with a protective layer of mucus, which also serves as a lubricant to aid in the passage of food.)

b. **Chief Cells.** Chief cells secrete digestive enzymes into the stomach.

(1) Pepsin. Pepsin, which begins the digestion of proteins, is the main enzyme secreted by the chief cells. Pepsin is produced inside the chief cells in an inactive form called pepsinogen. It is not until the pepsinogen enters the stomach and comes into contact with hydrochloric acid, that the pepsinogen is activated into active pepsin.

(2) Gastric lipase and rennin. Gastric lipase and rennin are secreted in such small quantities that they are of little importance. Rennin is an enzyme that aids in the digestion of casein, one of the proteins in milk. Gastric lipase begins the digestion of fats.

2−17. PANCREATIC SECRETION

a. **Hormone Regulation.** When food stimulates the upper part of the small intestine, two hormones, secretin and pancreozymin, are released which cause secretion by the pancreas. Secretin is a polypeptide hormone found in the mucosa of the upper small intestine. When chyme enters the intestine, it stimulates the secretion of secretin, which is absorbed by the blood. The hormone pancreozymin is also released by the mucosa of the upper small intestine; this secretion is particularly activated by the presence of proteoses and peptones. Pancreozymin also passes to the pancreas by way of the blood. Stimulation of the pancreas by pancreozymin causes the production of enzyme−rich pancreatic fluid; stimulation by secretin causes the production of watery, enzyme−poor pancreatic fluid, which contains bicarbonate to neutralize acid from the stomach.

b. **Pancreatic Enzymes.**

(1) Trypsin, chymotrypsin, and carboxypolypeptidase. Trypsin, chymotrypsin, and carboxypolypeptidase are proteolytic enzymes secreted by the pancreas. Trypsin and chymotrypsin split whole and partially digested proteins into amino acids and polypeptides. Carboxypolypeptidase hydrolyzes some polypeptides to amino acids.

(2) Pancreatic amylase. Pancreatic amylase hydrolyzes starches, glycogen, and other carbohydrates, with the exception of cellulose, and forms disaccharides.

(3) Pancreatic lipase. Pancreatic lipase hydrolyzes neutral fat into glycerol and fatty acids.

c. **Nervous Regulation.** When certain secretions are produced by the stomach, impulses are simultaneously transmitted by the vagus nerve to the pancreas. The pancreas in turn produces enzymes and releases them into the pancreatic acini where they are stored. When food enters the small intestine, the stimulus releases the stored enzymes.

2−18. INTESTINAL SECRETION

a. **Hormonal Control.** Food in the small intestine causes the secretion of a hormone known as enterocrinin. This hormone is said to stimulate the secretion of intestinal enzymes. Enterocrinin, however, is thought to be a very weak hormone and not of any great importance in the regulation of intestinal secretion.

b. **Intestinal Enzymes.** Over the whole surface of the small intestine are small tubular glands known as crypts of Lieberkuhn. At the base of these glands are located Paneth's cells which secrete the following digestive enzymes:

(1) Peptidase. Several different peptidases are formed in the small intestine, which serve the purpose of splitting polypeptides into amino acids.

(2) Disaccharidase. The disaccharidases (maltase, lactase, and sucrase) are formed in the small intestine for splitting their respective disaccharides (maltose, lactose, and sucrose) into monosaccharides.

(3) Intestinal lipase. Small amounts of lipase are formed in the small intestine to help split neutral fats into glycerol and fatty acids.

(4) Intestinal amylase. A small amount of amylase is produced in the small intestine. This amylase is used to break any remaining carbohydrates into disaccharides.

2–19. END PRODUCTS OF DIGESTION

a. **Carbohydrates.** Carbohydrates are finally absorbed as simple sugars, or monosaccharides.

b. **Proteins.** Proteins are broken down and absorbed as amino acids.

c. **Fats.** Fats are absorbed by the body in the form of fatty acids and glycerol.

2–20. ABSORPTION

Absorption occurs through the gastrointestinal mucosa by active transport and also by diffusion.

a. **Stomach.** Only small amounts of simple salts, alcohol, water, and glucose can be absorbed by the stomach.

b. **Small Intestine.** Over 90 percent of all digestion occurs in the small intestine. At the beginning of the small intestine are located numerous small villi. Since these structures are extremely vascular, they are able to absorb fluid and dissolved food material into the blood and the lymphatics.

c. **Large Intestine.** Though the small intestine is the site of most absorption in the gastrointestinal tract, about 500 mL of chyme passes into the large intestine each day. Of this, most of the water and electrolytes are absorbed in the colon. Only 50–100 mL of fluid is excreted in the feces. The main functions of the large intestine are to absorb water and electrolytes to form and store feces for elimination. In addition, bacterial activity in the large intestine is a source of vitamin K, vitamin B_{12}, thiamin, riboflavin, and gases. The formation of vitamin K is particularly important since there is an insufficient amount in the ordinary diet for adequate blood coagulation.

Section IV. THE URINARY SYSTEM

2–21. GROSS ANATOMY

a. **Location of The Kidneys.** The kidneys are flattened, bean–shaped, glandular organs about 4 inches long by 2 inches wide by 1 inch thick. They lie against the muscles of the back on each side of the vertebral column on the posterior wall of the abdomen, beneath the diaphragm, and behind the peritoneum (retroperitoneal). The right kidney is usually lower than the left. The kidney is supported by peritoneum anteriorly and by perirenal connective tissue posteriorly and laterally. Since the kidneys are under the dome of the diaphragm, they are afforded protection by the ribs.

b. **Gross Kidney Structure** (figure 2–10)**.** The large renal artery and renal vein enter the kidney at its central notch, the hilus. The kidney is composed of an outer shell called the cortex, and a hollow inner chamber called the pelvis. The cortex is firm, and is made up of more than a million tiny filtration plants called nephrons. As the pelvis leaves the renal sinus, it becomes smaller, and finally merges into the ureter. The medulla is made up of a series of striated, conical masses called the renal pyramids. The pyramids vary from eight to eighteen in each kidney, and they are situated with their bases directed to the circumference of the kidney, and their tops toward the pelvis.

c. **Ureters.** The pelvis of the kidney is drained by a tube called the ureter, which leaves the kidney at its hilus. The ureter drains the urine from the kidney to the urinary bladder.

d. **Urinary Bladder.** The urinary bladder is a muscular sac, which serves as a reservoir for urine and is located in the pelvic part of the abdomen. Its size varies with the amount of urine it contains. When empty, the bladder is shaped like a pear pointing downward; when moderately full (about 0.5 liter), it assumes an oval form. The urine enters from the two ureters at the back, and near the bottom of the bladder. The bladder empties through an opening at its midline. These three openings bound an area called the trigone. There are strong muscles in this central triangle of the bladder wall, essential for proper voiding. The bladder is supplied with a number of arteries, veins, and lymphatics, which are derived from abdominal blood vessels.

e. **Urethra.** The urethra drains the urine from the bladder to the outside. It usually is about six to eight inches long in the male, extending from the bladder to the end of the penis. In the female, the urethra is about 1 1/2 inches long. There are two circular cut-off muscles, or sphincters that keep the urine from leaking. One is situated around the neck of the bladder, and the other is around the membranous part of the urethra. The urethra is composed of a mucous membrane that is supported by submucous tissue, which connects it with the various structures through which it passes.

2-22. MICROSCOPIC STRUCTURE

a. **Nephrons.** Nephrons (figure 2-11) are the functional units of the kidney. Their main functions are to remove by filtration certain waste materials from the body, and to reabsorb water freed of waste for use in the body. The two main divisions of the nephron are the renal corpuscle and the tubular system.

b. **Renal Corpuscle.** The kidney contains large numbers of renal corpuscles. There are approximately one million of these structures in each kidney. Blood is carried to each corpuscle by an afferent arteriole that is a minute branch of the renal artery. This afferent arteriole divides into approximately 50 capillaries that are bent into short loops. This tangled mass of capillaries is referred to as the <u>glomerulus</u>. These capillaries converge into another fine vessel known as the efferent arteriole that carries the blood out of the glomerulus. This entire mass of capillaries, the glomerulus, is covered by a membranous sac called Bowman's capsule (which empties into the renal tubule), and the complete structure is known as a <u>renal corpuscle</u> (figure 2-12). It is from blood within the capillaries of the glomerulus that water, salts, glucose, urea, uric acid, creatinine, and other substances are filtered.

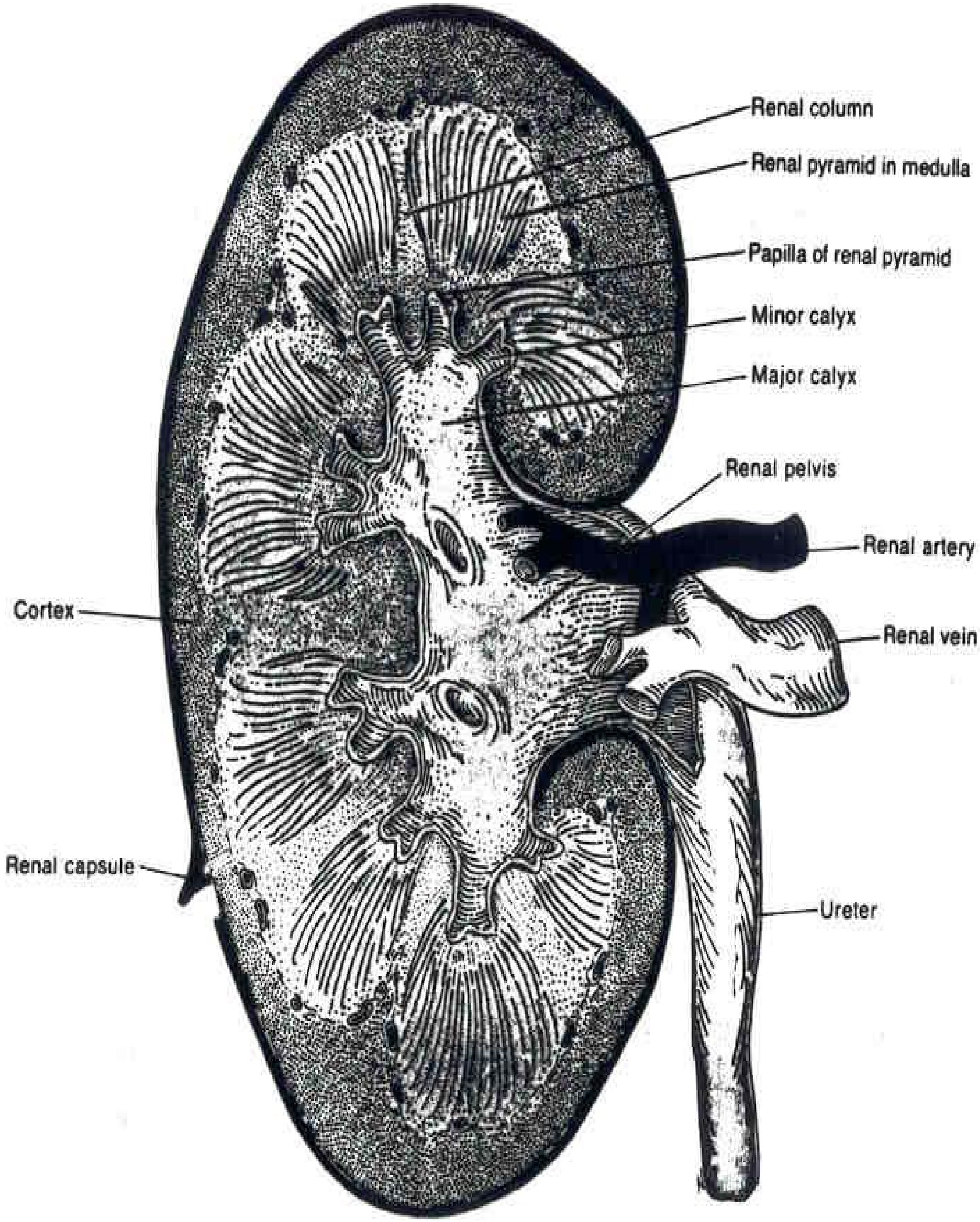


Figure 2-10. The kidney.

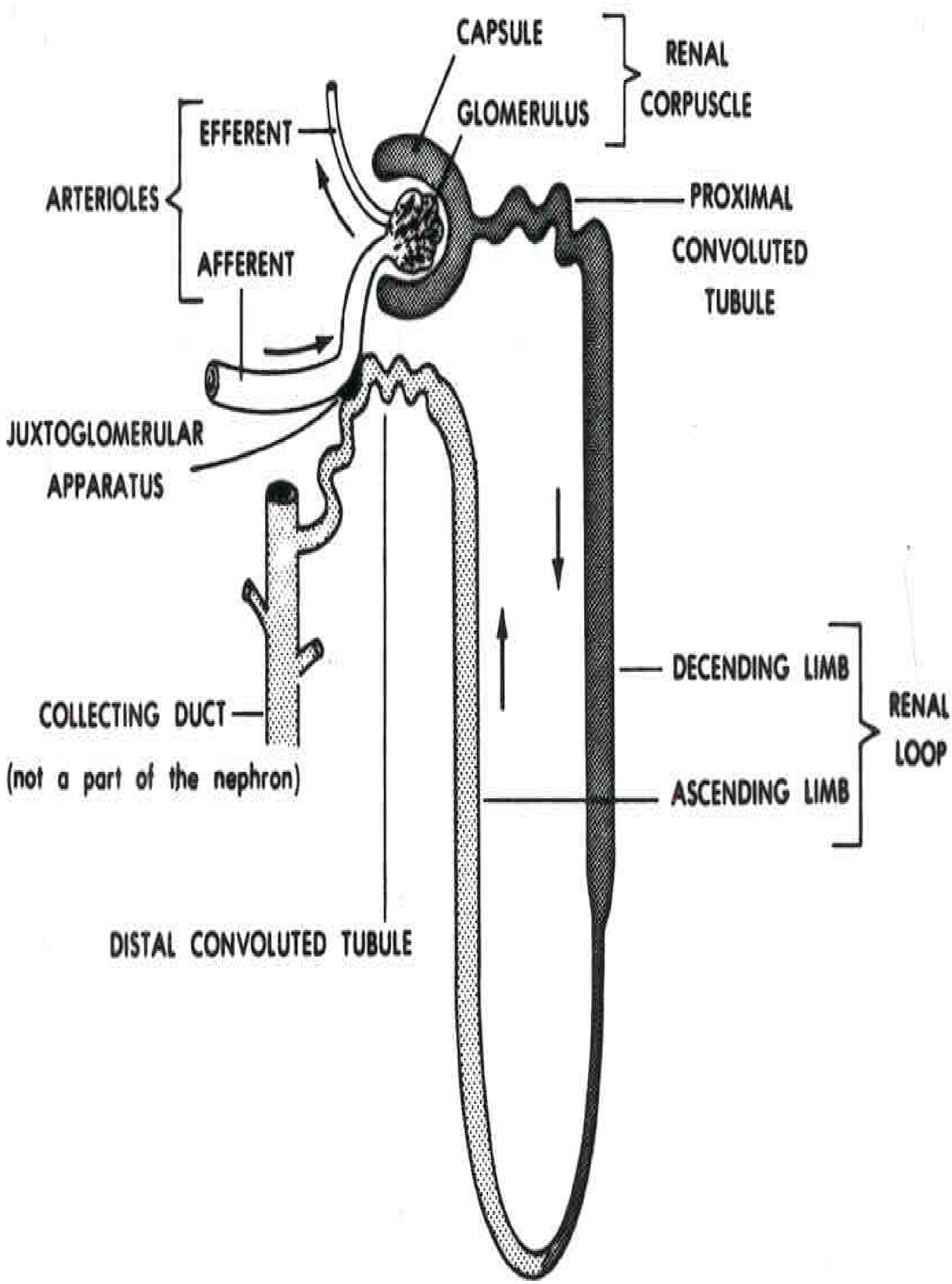


Figure 2-11. A nephron and its blood supply.

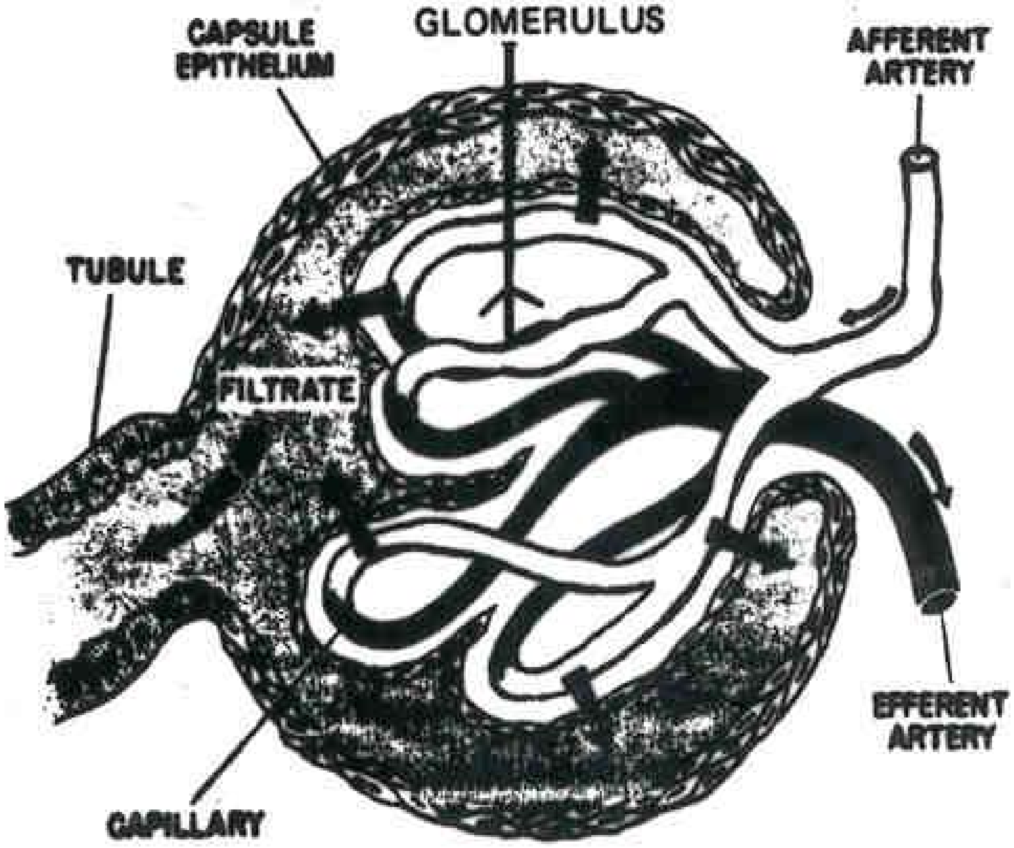


Figure 2-12. Renal corpuscle.

c. **Tubule.** Bowman's capsule is drained by the renal tubule. The first part of this tubule runs quite a distance in a coiled position and is called the proximal convoluted tubule. This portion eventually straightens and descends toward the medulla, but turns back again at a very sharp bend known as the loop of Henle. As the tubule ascends, it once again forms a coiled segment that is called the distal convoluted tubule. The distal convoluted tubules drain into a system of wide tubes called the collecting tubules. The renal corpuscles lie in the cortex, while Henle's loop and the collecting tubules lie in the medulla.

2-23. FLUID DYNAMICS

a. **Volume of Blood Flow.** Far more blood (25 percent of total cardiac output per minute) flows into the kidneys than is necessary for the provision of oxygen and nutrients to the kidney. In the kidney, the blood supplies not only the oxygen and nutrients but also a portion of blood is filtered by the kidney for processing. When severe stress is placed on the body due to hemorrhage, the blood flow to the kidneys is reduced, and very little urine is formed. The flow of blood is proportional to the quotient of the pressure drop and the vascular resistance.

b. **Renal Clearance.** A clearance value indicates the degree to which a substance is removed from the blood by excretion in the voided urine. Glomerular filtrate is practically identical to plasma, except that it contains very little protein. While 125 mL of glomerular filtrate is produced per minute, approximately 124 mL is reabsorbed by the renal tubules. Since none of the creatinine in the glomerular filtrate is reabsorbed, for example, we say that the plasma clearance of creatinine is 125 mL per minute. Another example follows: Less than 10 percent of the potassium ions is excreted (not reabsorbed); therefore, the clearance of potassium is said to be 12.5 mL per minute. The formula is:

$$\text{Plasma clearance} = \frac{\text{Milligrams excreted in urine per minute}}{\text{Concentration (mg/mL) in plasma}}$$

c. **Glomerular Filtration.** In humans, clearance tests are used to measure the rate of glomerular filtration. A substance is used that passes easily into the glomerular filtrate but is neither secreted nor reabsorbed by renal tubular cells. The concentration of such a material in the glomerular filtrate is approximately the same as the concentration of the material in the plasma. Knowledge of the rate of excretion of this material and the plasma concentration are the only factors necessary to compute the rate of glomerular filtration.

2–24. TUBULAR TRANSPORT

a. **Reabsorption.** The principal activity of the kidney is to transport dissolved materials and water across the tubular cells. Transport of materials from the renal tubules to the interstitial fluid is called reabsorption. Most tubular reabsorption occurs in the proximal convoluted tubule.

b. **Secretion.** The movement of dissolved materials and water from the interstitial fluid into the tubular lumen is called secretion.

c. **Passive Transport.** Passive transport occurs by two methods. Bulk flow occurs when an entire solution moves through a membrane taking all parts of the solution with it. Diffusion occurs when only certain components of a solution move across a membrane.

d. **Active Transport.** Active transport occurs when a dissolved material is forced across a rather impermeable membrane by a pumping mechanism. Most physiologically important solutes (glucose, amino acids, proteins, uric acid, and most electrolytes) are reabsorbed in this manner.

2–25. TRANSPORT OF SPECIFIC SUBSTANCES

a. **Urea.** Urea clearance test values are ordinarily about 70 mL per minute. Therefore, only about 50% of the urea in the glomerular filtrate is reabsorbed.

b. **Glucose.** Glucose reabsorption occurs in the proximal tubule and usually goes to completion at this point. Any glucose that is not reabsorbed in the proximal tubule is usually excreted.

c. **Sodium.** The reabsorption of sodium is by active transport and is associated with the reabsorption of Cl^- and HCO_3^-. Sodium is reabsorbed in exchange for H^+ and K^+. To preserve electrostatic equilibrium, it is necessary that for each Na^+ reabsorbed, there must be the reabsorption of an anion (Cl^- or HCO_3^-) or the secretion of a cation (H^+ or K^+).

d. **Chloride**. Chloride is reabsorbed in the proximal tubule. Chloride reabsorption is always incomplete, but it increases as the filtered load increases. About 80 percent of the sodium that is reabsorbed is in association with chloride.

e. **Hydrogen**. Hydrogen ions are secreted into the renal tubule. Hydrogen is secreted into the distal portion of the nephron in exchange as sodium is reabsorbed from the lumen. Hydrogen also serves to acidify the urine. H^+ secretion is an important pH regulatory mechanism.

f. **Potassium**. Reabsorption of potassium is probably by active transport. As sodium is reabsorbed from the lumen, interstitial potassium is secreted. Reabsorption of potassium occurs in the proximal tubule and secretion of potassium is into the distal tubule.

g. **Water**. Most of the water filtered from the plasma is reabsorbed in the proximal convoluted tubule. The flow of urine and the concentration of solute particles in the urine may vary widely. The concentration of solute in the urine depends on the concentration of antidiuretic hormone (ADH) in the plasma and on the rate of urine flow. The amount of ADH that is released depends on the concentration of solutes in the plasma. If the concentration is high, the hypophysis (posterior pituitary) releases ADH into the blood. When this hormone reaches the kidney, water reabsorption begins. If the concentration of solutes in the plasma is low, no ADH is released and water reabsorption decreases.

2–26. INTEGRATION OF TUBULAR FUNCTIONS

In the proximal convoluted tubule, the reabsorption of glucose and amino acids begins. Because of the active transport of sodium, chlorides and bicarbonate are reabsorbed. Approximately 90 percent of the sodium is reabsorbed in the proximal tubule. Water is reabsorbed in the proximal tubule as needed and determined by the concentration of solutes in the plasma. In the distal tubule, sodium is reabsorbed in exchange for hydrogen and potassium. The distal tubule is also permeable to water in the presence of ADH. When ADH is present, the collecting tubules also are permeable to water; but if ADH is not present, these tubules act only as conduits.

2–27. DIURESIS

A high rate of urine flow is called diuresis and there are two main types; water diuresis and osmotic diuresis. Water diuresis occurs when there are inadequate amounts of ADH in the blood. Osmotic diuresis is caused by an increase in the rate of solute excretion. An increase in solute excretion causes an increase in the amount of water that is excreted with the urine.

2–28. ENDOCRINE CONTROL

a. **Antidiuretic Hormone.** The effect of ADH on the permeability of water through the tubules is very rapid, and changes in the ADH concentration in the blood are only 10 to 15 minutes behind the change in the solute concentration.

b. **Renin and Aldosterone.** When the sodium concentration in the blood falls to a very low point or when the blood pressure falls (for example, in hemorrhage), special cells in the nephron release a hormone called renin which acts upon a plasma protein (angiotensinogen) to form angiotensin−2. Angiotensin−2, in turn, acts upon the cortex of the adrenal gland to produce aldosterone. Aldosterone increases Na^+ reabsorption and thus increases water reabsorption. This increases the plasma volume and the blood pressure.

Section V. THE ANATOMY AND PHYSIOLOGY OF RESPIRATION

2–29. THE ANATOMY OF THE RESPIRATORY SYSTEM (Figure 2−13)

a. **Nasal Cavity.**

(1) Structure. The nose contains the nasal cavity, which is divided by the nasal septum. The nasal cavity is separated from the mouth by the palate. The part of the nasal cavity just within the nostril is called the vestibule. The vestibule is lined with skin and coarse hair. The interior of the nose is lined with a highly vascular mucous membrane and very fine cilia.

(2) Functions.

(a) Filtering. The hair and cilia covering the nasal mucosa aid in removing dust and other solid particles from the air in its passage to the lungs. Air breathed through the mouth is not filtered as well.

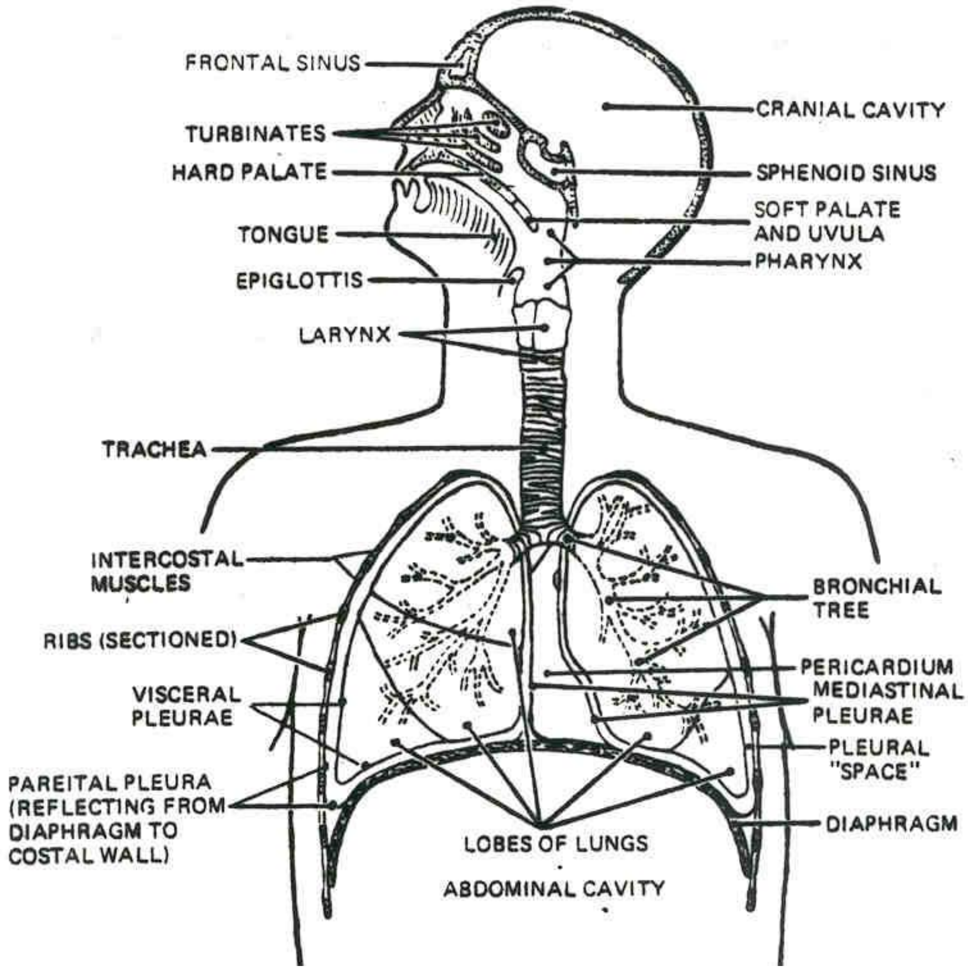


Figure 2-13. The respiratory system.

(b) Warming and moistening inhaled air. The air that is carried to the lungs is warmed in the nose by the capillaries that lie close to the surface of the mucous membranes. These membranes also serve to moisten the air and thus help to protect the alveoli (tiny air sacs) in the lungs.

(3) Paranasal air sinuses. These cavities are contained in several of the bones of the face and head. They are lined with mucous membrane, and they open into the nasal cavity. They are named according to the bone in which they are found. The sinuses have several functions. They help to warm inspired air before it reaches the lungs, they act as resonance chambers for the voice, they supply mucus for moisture, and they lighten the skull.

b. **Mouth.** Air can also enter the lungs by way of the mouth, but the mouth does not as efficiently moisten, warm, or remove foreign particles from the air.

c. **Pharynx.**

(1) Nasopharynx. The nasopharynx, one of the three parts of the pharynx, is located directly behind the nasal cavities. The nasopharynx connects the pharynx with the posterior nares (openings between the nasal cavities and the nasopharynx) and the eustachian tubes (which connect the tympanic cavities of the ear with the nasopharynx). The nasopharynx is the part of the pharynx, which lies above the soft palate.

(2) Oropharynx. The oropharynx is the part of the pharynx lying between the soft palate and the upper edge of the epiglottis.

(3) Laryngopharynx. The laryngopharynx, which opens into the trachea and esophagus, is the part of the pharynx, which lies below the upper edge of the epiglottis.

d. **Larynx.** The larynx, or "voice box," is termed the "Adam's apple" and is prominent in the male. The larynx is located in front of the pharynx and above the beginning of the trachea. The framework of the larynx is entirely cartilaginous and consists mainly of the thyroid and cricoid cartilages.

(1) Glottis. The larynx contains the vocal cords which produce the voice. Sound is produced by the exhalation of air. The space that is present between the vocal cords is known as the rima glottidis, or simply the glottis. During ordinary breathing the part of the glottis between the vocal cords is relatively wide and triangular, the apex of the triangle being in front.

(2) Epiglottis. The epiglottis is a leaf shaped piece of fibroelastic cartilage that lies behind the tongue. Its free, rounded end projects upwards behind the back of the tongue. Its slender, stemlike lower end is attached by a ligament to the upper part of the thyroid cartilage. The epiglottis helps to close off the trachea during swallowing.

e. **Trachea.** The trachea, or windpipe, is a smooth tube, which transports the air to the lungs. Embedded in this tube are cartilaginous rings, which are closed anteriorly, and open posteriorly. These semicircles are about three-fourths inch in diameter, and serve the function of keeping the trachea open at all times. The rings are open posteriorly (but connected by smooth muscle and connective tissue) to facilitate swallowing in the adjacent esophagus. The trachea begins at the lower border of the larynx, and passes behind the sternum into the thorax. The tube is lined by a mucous membrane.

f. **Bronchi.** As the trachea continues downward into the thoracic cavity, it bifurcates into two bronchi, the right bronchus and the left bronchus. An inflammation of the mucous lining of the bronchi is termed bronchitis.

g. **Bronchioles.** As the bronchi enter the lungs at the hilum (depression or pit) of each lung, the bronchi divide into innumerable branches of progressively diminishing size, until divisions of very narrow diameter are reached, and these are termed bronchioles. The bronchi and the bronchioles are lined by a mucous membrane of ciliated, columnar epithelium that is continuous with the lining of the trachea. The entire length of the bronchial tree is richly supplied with elastic fibers.

h. **Alveolar Ducts and Sacs.** Bronchioles run into smaller branches, which are known as alveolar ducts. These lead to small spaces called alveolar sacs.

i. **Alveoli.** The walls of the alveolar sacs are lined with tiny "cubicles," called alveoli. The walls of the alveoli are thin enough to allow the easy passage of gases. The alveoli are in contact with a plexus of capillaries. The alveolar sacs, which are in contact through the bronchial tree with the atmosphere, are continually filled with air. It has been estimated that each lung contains seven million alveoli.

j. **Lungs.**

(1) Lobes. The lungs are two in number (right and left) and are contained in the thoracic cavity. The lungs are cone-shaped organs with their apexes pointed toward the base of the neck. The base of the lung conforms to the convex surface of the diaphragm. The lungs overlap the greater portion of the heart. The right lung is divided into three lobes by two fissures. The left lung is divided into two lobes by one fissure. The apex of the heart continually pushing against the left lung has eliminated a lobe during embryological development. On the surface of each lung is a depression called the hilum. At the hilum, the structures that comprise the root of the lung enter and leave the lung. These structures are a bronchus, the pulmonary artery, two pulmonary veins, bronchial arteries and veins, lymphatics, nerves, and lymph nodes. The lungs are bounded superiorly by the upper portion of the thorax, inferiorly by the diaphragm. They are also bounded laterally, anteriorly, and posteriorly by the ribs and intercostal muscles, sternum, and vertebral column.

(2) Pleura. Each lung is covered by a membrane, called the pleura, composed of a single layer of endothelial cells lying upon a delicate connective tissue membrane. The lung may be pictured as having been pushed into the side (not into the interior) of a closed membranous sac. The lung is thus covered by two layers of the pleura. Between the pleural layers is found the pleural cavity. The two layers of pleura are in contact with each other except for a thin film of serous fluid known as pleural fluid. This fluid allows the lung to inflate and deflate without any friction. Inflammation of the pleural membrane is called pleurisy.

(a) Visceral. The pleural layer adherent to the lung is called the visceral pleura.

(b) Parietal. The pleural layer lining the thoracic cavity is called the parietal pleura.

k. **Diaphragm.** The diaphragm is the most important muscle connected directly with the respiratory system. It is a dome-shaped muscle, which lies between the abdominal and thoracic cavities and completely separates the two cavities. As you inhale, the diaphragm tends to flatten out thus helping to draw more air into the lungs. The visceral pleura is pulled down as the diaphragm flattens out. As you exhale, the diaphragm assumes its original dome shape, pushed up by the viscera.

l. **Ribs.** The intercostal muscles (between the ribs) assist the breathing mechanism. These structures enlarge the lung cavity laterally, anteriorly, and posteriorly. Thus, the ribs and their muscles, along with the diaphragm, constitute the main part of the mechanical process of breathing.

2–30. MECHANICS OF BREATHING

a. **Control Center.**

(1) Medulla. The portion of the brain that controls respiration is the lower portion of the brain, the medulla oblongata.

(2) Phrenic nerve. In connection with and coming from the medulla oblongata are the right and left phrenic nerves which run from the brain to the diaphragm. If one of these nerves is severed, the corresponding portion of the diaphragm ceases to function.

b. **Breathing.**

(1) Inhalation. Inhalation occurs when the diaphragm contracts and its domed upper surface flattens out and, as a result, the size of the chest cavity increases. This causes decreased pressure in the chest cavity and a partial vacuum in the lungs; thus, air is drawn into the lungs. The contraction of the diaphragm is accompanied by the contraction of certain muscles of the chest wall, particularly the intercostal muscles between the ribs. The contraction of the intercostal muscles causes the chest cavity to enlarge from side to side and from front to back, and thus assist in expanding the lungs. These muscles, then, are accessory muscles of respiration.

(2) Expiration. Expiration of air from the lungs is a passive process caused by the relaxation of the diaphragm, which moves upward, and by the relaxation of the accessory muscles, allowing the ribs to compress the lungs. This action causes the thoracic cavity to decrease in size so that the air in the lungs is driven out, due to the greater pressure. Then the cycle repeats itself.

c. **Respiration.** Respiration is a complex process by which oxygen is supplied to the tissues and CO_2 removed. Respiration involves the following processes:

(1) Pulmonary ventilation, which is concerned with the distribution and volume of air ventilating the alveoli.

(2) Gas exchange of O_2 and CO_2 between the alveoli and blood by diffusion through the pulmonary membrane.

(3) Transport of blood and body fluids to and from the body cells.

(4) Regulation of circulatory and ventilating systems by specific neuronal structures in response to changes in their environment.

d. **Lung Volumes Associated with Breathing.** There exist certain volume changes associated with breathing that can be accurately recorded by an instrument called a spirometer. The tidal volume is the volume of air exchanged in normal breathing and is approximately 500 mL. The inspiratory reserve volume is the extra volume of air that can be inspired over and beyond normal tidal volume and is approximately 3,100 mL. Expiratory reserve volume is the amount of air that can still be expired forcefully, after normal tidal expiration is approximately 1,200 mL. Vital capacity is the sum of tidal volume, inspiratory reserve volume and expiratory reserve volume. After forceful expiration, the lungs still contain a given amount of air that is termed the residual volume. This volume averages 1200 mL.

2−31. EXCHANGE OF GASES

As blood passes through the lungs, the concentration of oxygen (P_{O2}) and the concentration of carbon dioxide (P_{CO2}) become nearly equal to the P_{O2} and the P_{CO2} of the air in the lungs. That is, since the concentration of oxygen in the atmosphere is greater than the concentration of oxygen in the blood, the oxygen moves into the blood in an attempt to equalize the concentrations. Likewise, since the concentration of carbon dioxide in the blood is greater than the concentration of carbon dioxide in the atmosphere, the carbon dioxide moves from the blood to the air in an attempt to equalize the pressure. Dalton's Law explains this partial pressure principle.

2−32. OXYGEN TRANSPORT

As oxygen diffuses into the pulmonary blood, it is mainly transported by the blood in combination with hemoglobin. Although only 2.3 mL of oxygen per 100 mL of blood is present due to the partial pressure principle, an additional 20.1 mL of oxygen per 100 mL of blood can be transported in association with hemoglobin.

2−33. CARBON DIOXIDE TRANSPORT

Only about 5 percent of the carbon dioxide in the blood is transported in the dissolved state. About 95 percent of the carbon dioxide enters the red blood cells (RBCs) where it undergoes one of two reactions.

a. The first reaction is as follows:

$$CO_2 + H_2O \xrightarrow{\text{carbonic anhydrase}} H_2CO_3 \text{ (carbonic acid)}$$

$$H_2CO_3 \longrightarrow H^+ + HC0_3^- \text{(bicarbonate ion)}$$

The bicarbonate ion is formed due to the pH of red blood cells, which is maintained by buffer systems. Once formed, the bicarbonate ions diffuse back into the plasma. About 60 percent of the carbon dioxide is transported in the plasma as bicarbonate ion.

b. The second reaction is as follows:

$$CO_2 + \text{hemoglobin} \longrightarrow \text{carbaminohemoglobin}$$

Actually, very little carbon dioxide is transported in association with hemoglobin.

c. An unusual chemical phenomenon occurs in deoxygenated RBCs. It is accepted that cells of our body possess "sodium pumps" which constantly remove sodium ions from cells. To balance the lost positive charge, chloride ions generally follow sodium ions and are in high concentrations in the extracellular fluids. In deoxygenated RBCs, the concentration of carbonic acid is high. As carbonic acid ionizes, bicarbonate ions move out of corpuscles at an increased rate. To compensate for the loss of negative charges inside RBCs, chloride ions move from the extracellular fluid into the blood corpuscles. This phenomenon is termed the chloride shift.

Section VI. THE NERVOUS SYSTEM

2-34. GENERAL

a. **Introduction.** The nervous system is made up of tissue specialized to respond to stimuli by conducting impulses. The unit of structure is the nerve cell (neuron), which consists of a cell body and its nerve fibers (figure 1-10). Neurons are classified according to their functions. An association neuron is one that carries impulses from one part of the central nervous system (brain and spinal cord) to another. An afferent (sensory) neuron is one that carries impulses from a receptor (sense organ) to the central nervous system. An efferent (motor) neuron is one that carries impulses from the central nervous system to an effector (a muscle or gland), causing it to act. The nervous system is the integrating mechanism for intellectual and physical activities.

b. **Divisions of the Nervous System.** For the purpose of study, parts of the nervous system may be considered separately--the central nervous system, the peripheral nervous system, and the autonomic nervous system.

2–35. CENTRAL NERVOUS SYSTEM

The central nervous system is composed of the brain and the spinal cord (figure 2–14).

a. **Meninges.** Surrounding the brain and spinal cord are three layers of protective membranes known as the meninges. The outer layer, called the dura mater, forms a tough lining just inside the skull and the vertebrae. The middle layer is the arachnoid. The inner layer, the pia mater, is closely in contact with the surface of the brain and cord. The subarachnoid space between the arachnoid and the pia mater contains the cerebrospinal fluid.

b. **Brain.** The brain consists of four main parts--the cerebrum, the cerebellum, the pons, and medulla oblongata (figure 2–15).

(1) Cerebrum. The cerebrum is made up of the right and left cerebral hemispheres. The outside surface is called the cerebral cortex. It is the so–called "gray matter" because it is made up of nerve cell bodies that are pigmented. The cortex is thrown into folds called convolutions or gyri, separated from each other by grooves or fissures known as sulci. These grooves divide the surface of the cerebrum into lobes, chief of which are the frontal lobe, the parietal lobe, the temporal lobe, and the occipital lobe (figure 2–16). Certain areas of the cerebrum are localized for certain functions. In the frontal lobe, anterior to the central fissure, is the motor area, which controls voluntary movements of the body; the speech center; and the writing center. A great portion of the frontal lobe is believed to be the seat of intelligence, memory, and the association of ideas. In the parietal lobe, posterior to the central fissure, is the general sensory area that receives sensations of heat, cold, touch, pressure, pain, and position. In the temporal lobe are the centers for the sensations of hearing, tasting, and smelling. In the occipital lobe is the visual center.

(2) Cerebellum. The cerebellum lies below the posterior part of the cerebrum behind the pons and the medulla oblongata. Its surface is not convoluted like that of the cerebrum, but is characterized by a cortex of gray matter having sulci of varying depth. The cerebellum serves as a coordinator of muscular activity, a regulator of muscle tone, and a center for reflex action and for equilibrium. The cerebellum exerts considerable control over the posture of the individual. When the cerebellum is removed from lower animals, they cannot walk.

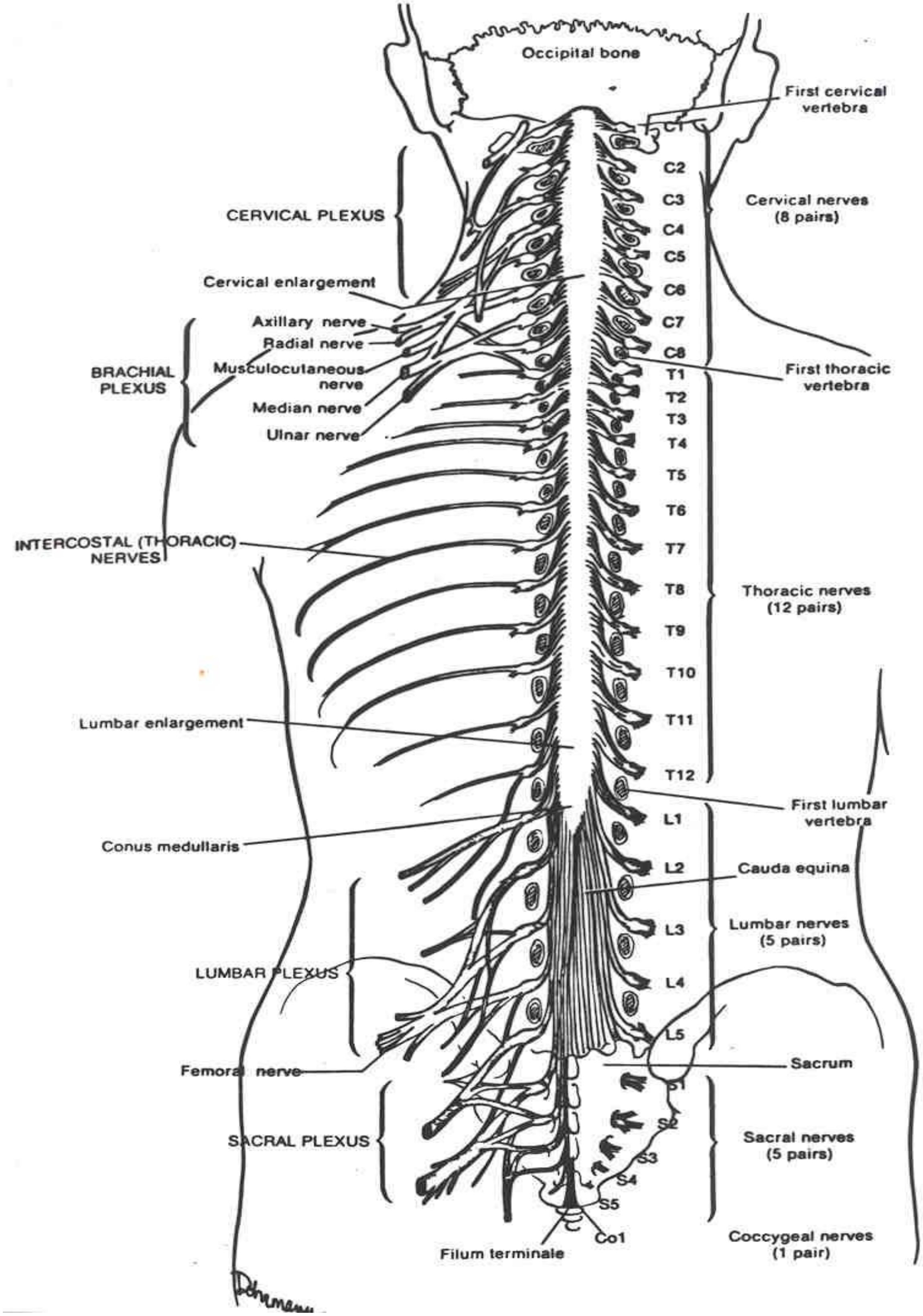


Figure 2-14. Principal nerve trunks.

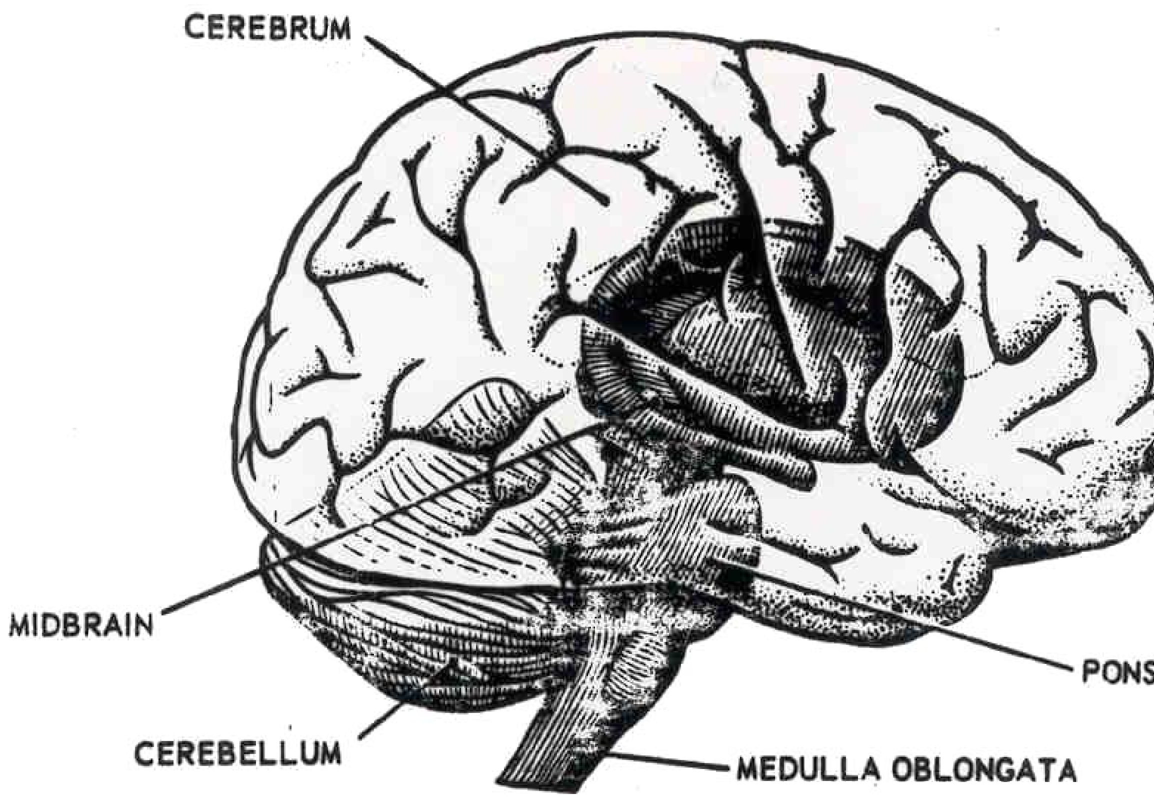


Figure 2-15. The main parts of the brain.

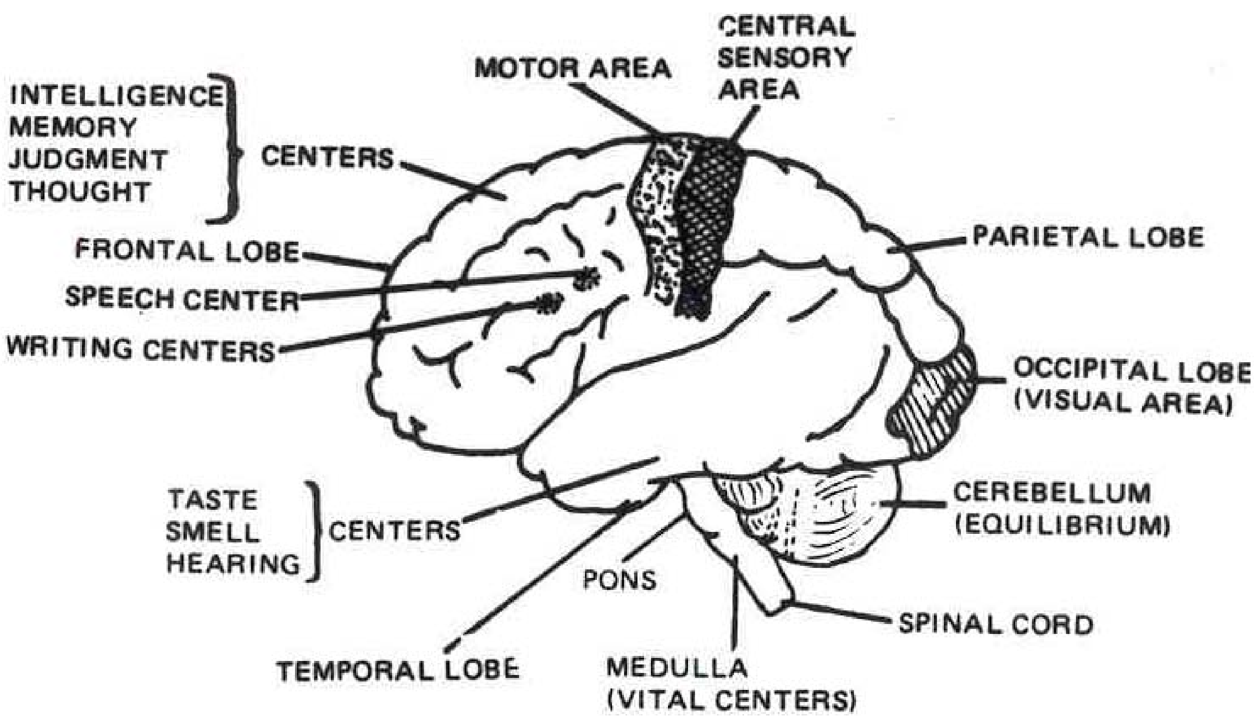


Figure 2-16. Functional centers of the brain.

(3) Pons. The pons lies in front of the cerebellum and is continuous with the medulla oblongata, although separated from it in front by a shallow furrow. "Pons" means bridge, and it is actually a bridge of tissue. Nerve tracts go through the pons, conveying sensory impulses to the cerebral cortex, and motor impulses away from it.

(4) Medulla oblongata. The medulla oblongata is the lowest part of the brain, extending from the pons to the spinal cord. It is pyramidal in shape and contains nerve tracts between the spinal cord and the cerebellum. There are several vital centers in the medulla: the vasomotor center, for control of the blood pressure; the cardioinhibitory center, for control of the heart rate through the vagus nerve; the respiratory center, for control of rate and depth of respiration, and control of respiratory movements through the vagus, the phrenic, and the intercostal nerves; and the temperature control center for the control of body heat. Several of the nerves that leave the brain through the skull−−without going down the spinal cord−−come from the medulla and the pons. These are the cranial nerves.

c. **Ventricles** (figure 2−17). Within the brain is a system of intercommunicating cavities called the ventricles which are filled with cerebrospinal fluid. The lateral ventricles are in the cerebral hemispheres on either side. They are connected with each other by an opening which also empties into the centrally located third ventricle. The third ventricle, in the midbrain, is triangular in shape and empties below and behind, into the fourth ventricle. The fourth ventricle is in front of the cerebellum, and behind the pons and the upper half of the medulla oblongata. On the roof of this ventricle are three openings through which the cerebrospinal fluid flows into the subarachnoid space of the brain and spinal cord.

d. **Spinal Cord.** The spinal cord is that part of the central nervous system within the vertebral column; it extends from the medulla oblongata to the level of the second lumbar vertebra. If a transverse section of the cord is examined, the white and gray matter composing it can be seen. The gray matter is in the interior of the cord, in the shape of an H (figures 2−18 and 2−19). Within the gray matter lie the cell bodies. The posterior horns contain the cells of sensory nerves, and the anterior horns contain cells of motor nerves. The white matter surrounding the gray matter is composed of bundles of nerve fibers, motor, and sensory, which are the nerve tracts of the cord. The ascending nerve tracts contain sensory nerves, and carry various kinds of sensations to the brain, such as pain, temperature, and posture. The descending nerve tracts contain motor nerves, and control either voluntary or involuntary activities of the muscles, the glands, and the organs. Most of these tracts (both ascending and descending) cross over to the opposite side before reaching the brain.

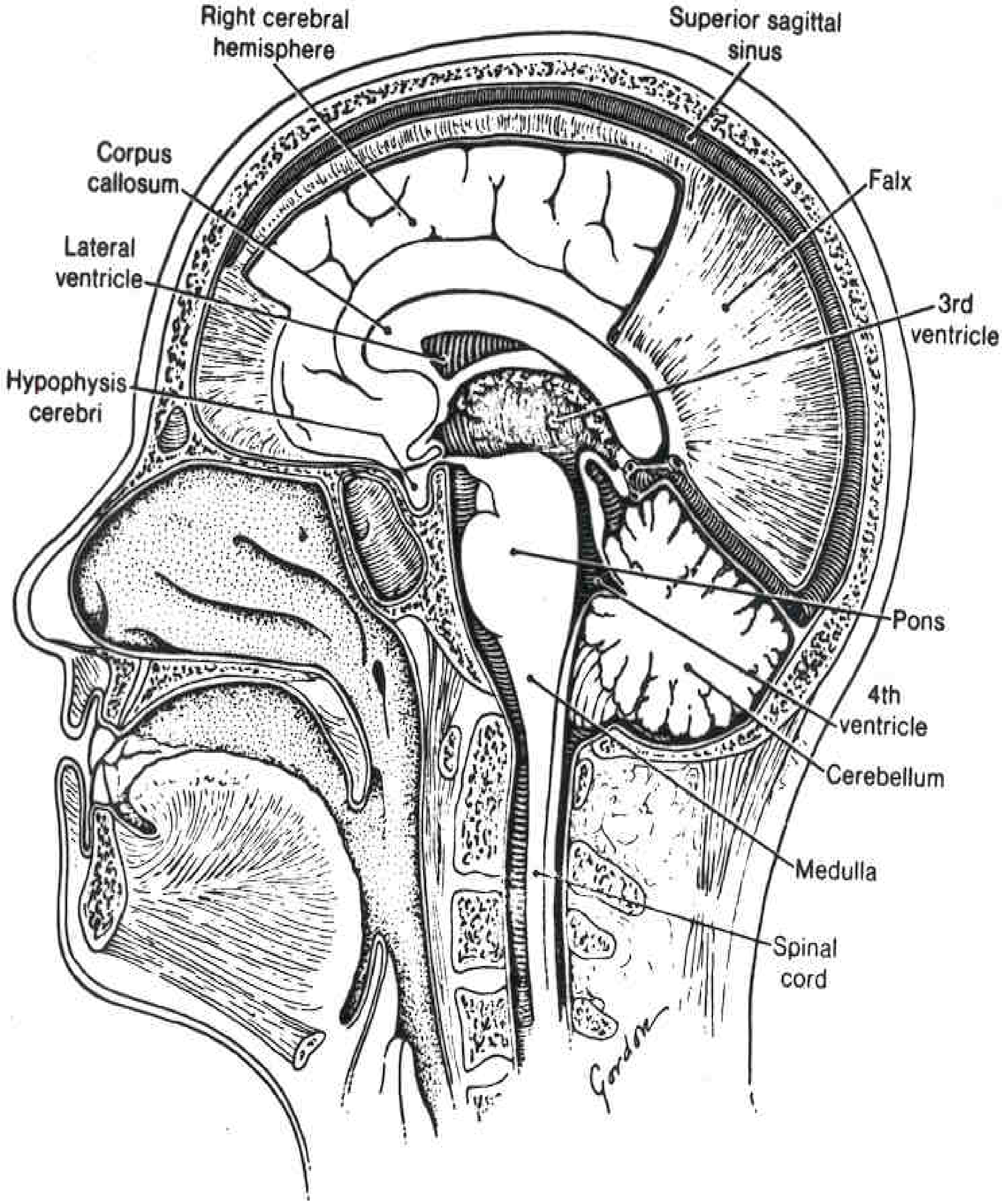


Figure 2-17. The brain, sagittal section.

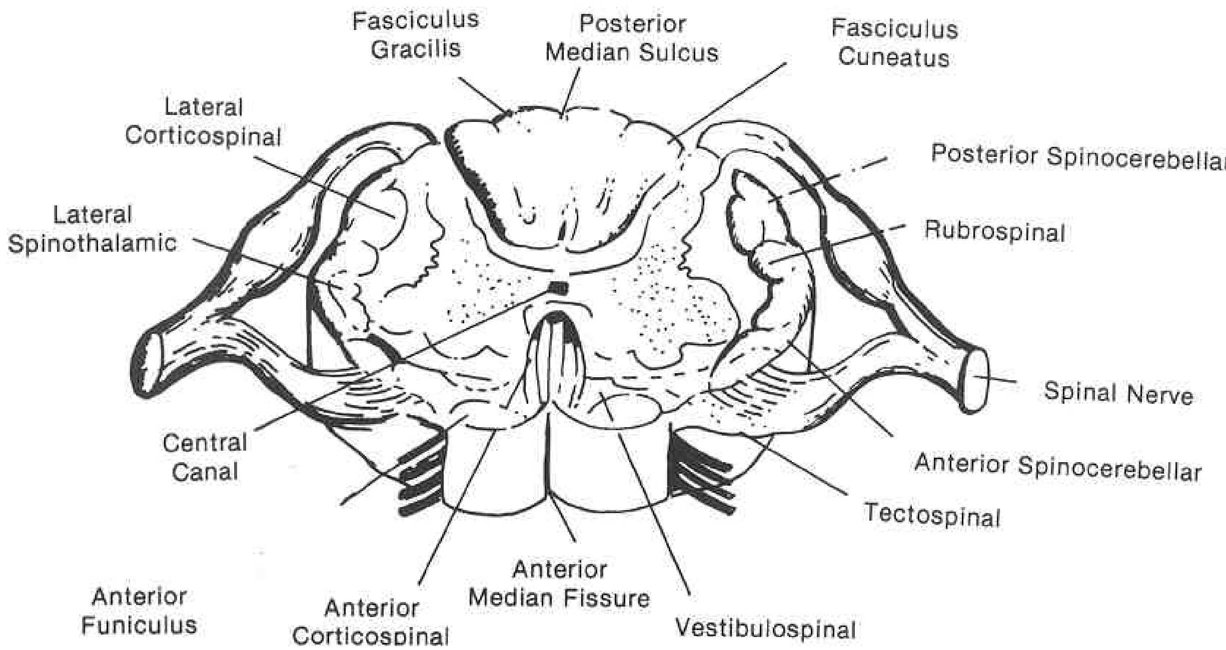


Figure 2-18. A cross section of the spinal cord.

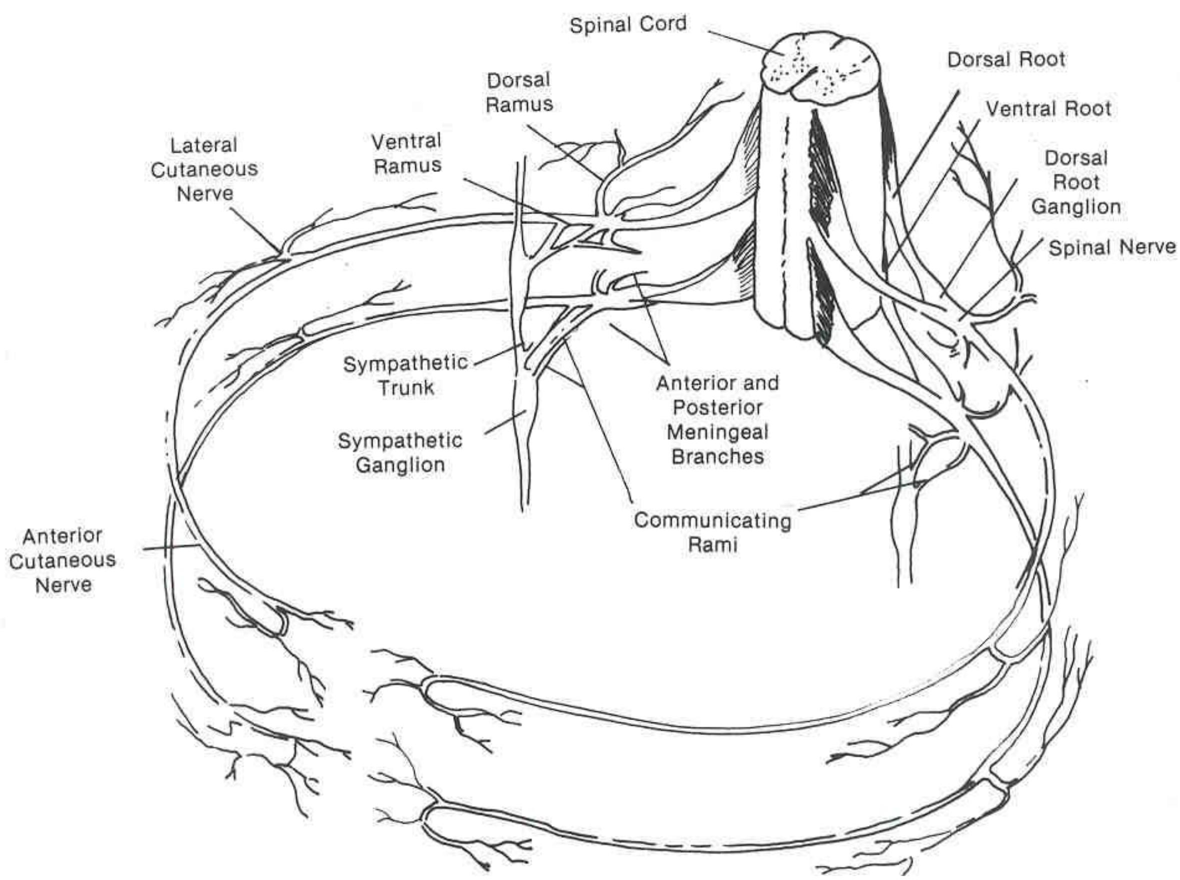


Figure 2-19. Relationship of the sympathetic and spinal nerves.

2–36. CEREBROSPINAL FLUID

a. **Formation and Reabsorption.** Cerebrospinal fluid (CSF) is produced predominantly by small masses of blood vessels known as choroid plexuses. Choroid plexuses are found in chambers of the brain (first, second, third, and fourth ventricles). The composition of the choroid secretion is similar to interstitial fluid with the exception that the sodium concentration is 7 percent greater, potassium 40 percent less, and glucose usually 30 percent less. Cerebrospinal fluid fills the four ventricles of the brain and the subarachnoid space and surrounds the spinal cord. Within the subarachnoid space are arachnoid villi, which absorb cerebrospinal fluid and return lost proteins and electrolytes to cerebral veins. Approximately 750 mL of CSF are formed per day while only about 135 mL are needed to fill the subarachnoid space.

b. **Functions.** Cerebrospinal fluid functions primarily to protect the brain by cushioning it against external blows to the skull. Secondly, the cerebrospinal fluid system is similar to the lymphatic system in that it returns lost proteins and nutrients to the bloodstream.

c. **Pathology.** Occasionally, inflammation of the membranes (meningitis) surrounding the brain and spinal cord occurs due to a number of types of microorganisms. Spinal taps are therefore performed by physicians, and CSF is analyzed for bacterial or viral infections. Another type of malfunction associated with the CSF system is the disease hydrocephalus. Generally, one of the ducts between the ventricles in the brain becomes blocked. The CSF accumulates within the brain causing chronic edema. In young children, bones of the skull separate and the head become greatly enlarged.

2–37. PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system, although it communicates with the brain and spinal cord, is distributed outside of, and around (peripheral to) the central nervous system, hence its name. The peripheral nervous system includes the 12 pairs of <u>cranial nerves</u> and the 31 pairs of <u>spinal nerves</u>, stemming from the brain and spinal cord respectively. The nerve fibers carry both voluntary and involuntary impulses. (The latter belong to the autonomic system and will be discussed separately.) Not every nerve necessarily has both types of fibers. The cranial nerves are mostly voluntary, except for those few involuntary fibers going to the ciliary eye muscles, the salivary glands, the heart, the smooth muscles of the lung, and to the gastrointestinal tract. The spinal nerves have voluntary fibers going to all skeletal muscles of the trunk and extremities, and involuntary fibers going to the smooth muscles and to the glands of the gastrointestinal tract, the genitourinary system, and the cardiovascular system. The voluntary fibers carry impulses that are stimulatory, and cause a contraction of a muscle.

2–38. AUTONOMIC NERVOUS SYSTEM

The autonomic nervous system is that part of the nervous system which controls the activity of cardiac and smooth muscle, sweat and digestive glands, and some of the endocrine glands. Its control over these reactions is almost wholly involuntary, yet the behavior of the autonomic system reflects somewhat the activity of the central nervous system, for the two are connected. The autonomic nervous system is divided into the sympathetic and the parasympathetic systems.

a. **Sympathetic System.** A number of ganglia (nerve centers) are the basis of the sympathetic system. These are located just outside the spine, beside each vertebra, and extend from the first thoracic to the third lumbar segments. These ganglia are connected with the spinal nerves by a fiber from a nerve cell in the lateral horn (sensory) of the spinal cord. From this ganglion comes a nerve fiber that runs with the motor fibers from the anterior horn to the muscles, organs, and glands (figure 2-19).

b. **Parasympathetic System.** The ganglia of the parasympathetic system are located in the midbrain, the medulla oblongata, and in the sacral region. The fibers in the midbrain and the medulla send out impulses through cranial nerves (oculomotor, facial, glossopharyngeal, vagus). The cells comprising the sacral ganglia stem from the second, third, and fourth sacral nerves.

c. **Function of the Autonomic Nervous System**.

(1) The function of the sympathetic system is to increase the activity of the organs of the body, enabling it to meet danger and to undergo strenuous physical activity. The effects of the parasympathetic system are opposite to those of the sympathetic system (see Table 2-1). The opposing functions of these two parts of the autonomic nervous system balance each other.

(2) During a period of quiet, the effect of the parasympathetic system is predominant. During a period of danger, emotional crisis, or strenuous exercise, the sympathetic system is in control. The effects of sympathetic action are apparent in the individual as the symptoms of anger, of fear, or of exhilaration. It is a useful mechanism that helps the individual in a period of stress.

SYMPATHETIC	PARASYMPATHETIC
1. Dilates pupils.	1. Contracts pupils.
2. Lessens tonus of ciliary muscles so that the eyes are accommodated to see distant objects.	2. Contracts ciliary muscles, so that the eyes are accommodated to see objects near at hand.
3. Dilates bronchial tubes.	3. Contracts bronchial tubes.
4. Quickens and strengthens the action of the heart.	4. Slows the action of the heart.
5. Contracts blood vessels of the skin and viscera so that more blood goes to the muscles where it is needed for "fight or flight."	5. Dilates blood vessels.
6. Inhibits peristalsis. Food "sits like a lump" in the stomach.	6. Increases peristalsis.
7. Decreases secretions of glands (except the sweat glands and the adrenal glands, which secrete more).	7. Increases secretions of glands (except the sweat glands and the adrenal glands).
8. Causes contraction of sphincters to prevent emptying of bowels or bladder.	8. Relaxes sphincters so that waste matter can be removed.

Table 2-1. Functions of the autonomic nervous system.

Section VII. THE ENDOCRINE SYSTEM

2-39. ENDOCRINE GLANDS

Hormones are produced by specialized glands called endocrine, or ductless, glands (figure 2-20) and are secreted directly into the bloodstream. Glands such as the salivary, mucous, and gastric glands produce substances, which they secrete by means of ducts into the organ on which they are to act. They are glands of external secretion. The hormone-producing endocrine glands are glands of internal secretion since they do not secrete their products into an organ or cavity but directly into the blood or lymph. Table 2-2 lists the ductless glands along with their locations and the substances which they secrete.

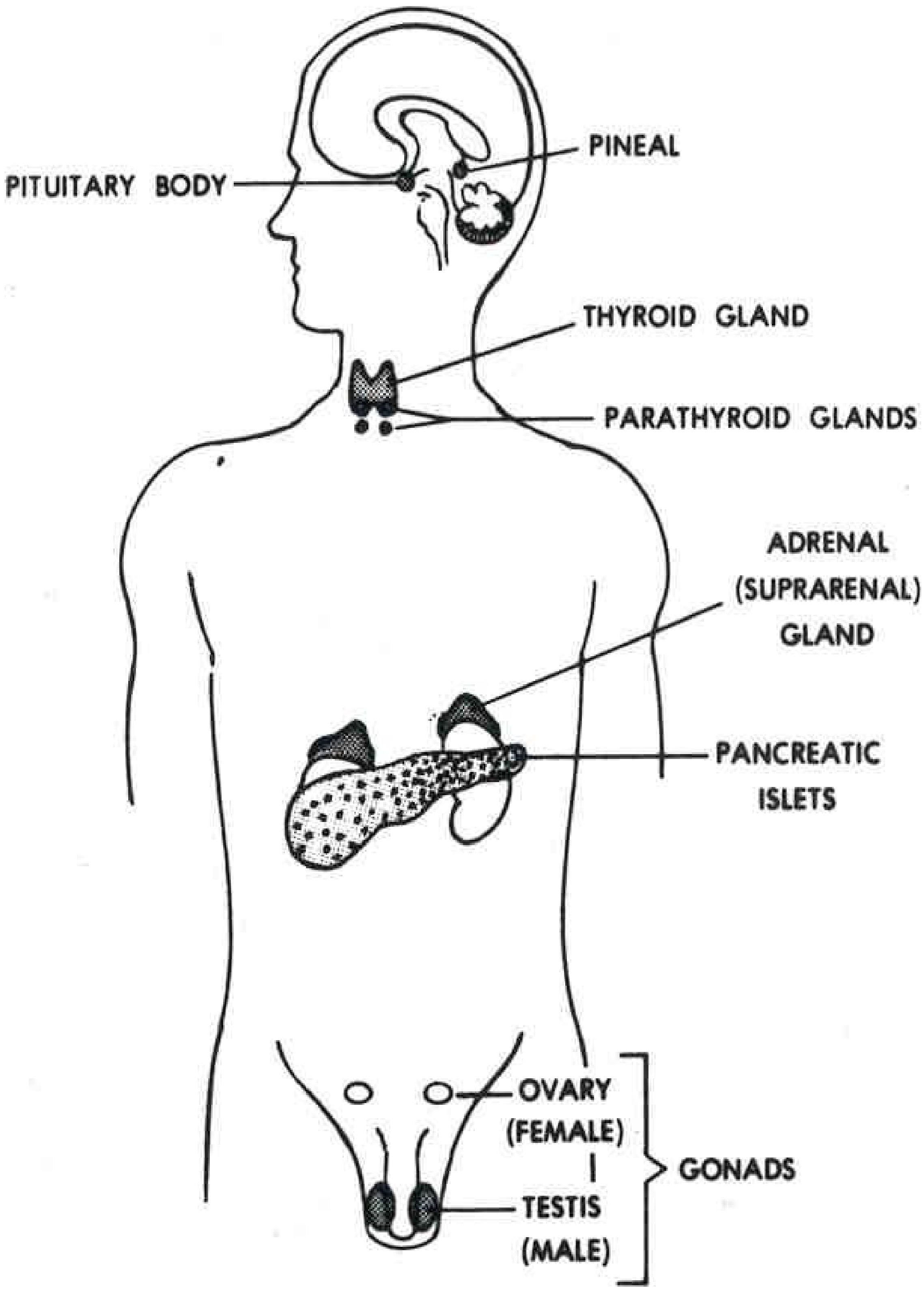


Figure 2-20. Endocrine glands.

THE GLAND	LOCATION	SUBSTANCE SECRETED
ADRENAL MEDULLA	ATTACHED TO THE UPPER KIDNEYS	EPINEPHRINE
ADRENAL CORTEX		HYDROCORTISONE; ALDOSTERONE; CORTICOSTERONE
a. OVARY GONADS b. TESTES	a. NEAR LATERAL WALL OF PELVIS b. SUSPEND OUTSIDE ABDOMEN	a. ESTROGENS PROGESTERONE b. ANDROGENS
PANCREAS (ISLET CELLS)	BEHIND STOMACH	INSULIN GLUCAGON
PARATHYROID	BACK SURFACE OF THYROID GLAND	PARATHORMONE
PINEAL	BETWEEN FOLDS OF THE BRAIN	MELATONIN
ANTERIOR PITUITARY (ADENOHYPOPHYSIS) POSTERIOR PITUITARY (NEUROHYPOPHYSIS)	BEHIND THE OPTIC NERVE, CROSSING POINT ON THE BRAIN	GROWTH HORMONE, THYROTROPIN (TSH), CORTICOCOTROPIN (ACTH), FOLLICLE-STIMULATING (FSH), LUTEINIZING HORMONE, LUTEOTROPIC HORMONE, PROLACTIN, OXYTOCIN, VASOPRESSIN (ADH)
THYMUS	UPPER THORAX NEAR THROAT	THYMOSIN
THYROID	NECK, EITHER SIDE OF ESOPHAGUS	THYROXINE CALCITONIN

Table 2-2. Names, locations, and secretions of the endocrine glands.

2-40. FUNCTIONS OF HORMONES

To ensure harmonious interaction of the various organs of the body and thereby maintain homeostasis (a stable condition in the internal environment), communication between the organs must be established. Chemical substances known as hormones act as messengers in the body. In general, hormones, regardless of the gland from which they are secreted, may:

a. Increase or decrease the activities of other glands.

b. Stimulate or retard the metabolism in general.

c. Influence the growth or development of the whole body or a particular part of it. Hormones have a profound effect on growth, development, physical and mental well-being, and personality. When hormones are absent from the body, due to malfunction of a gland or any other reason, or when they are manufactured and secreted in excess due to hypertrophy of an organ, serious disturbances and diseases result.

2-41. THYROID

The thyroid is bilobate and lies in front of and on either side of the trachea. It secretes the hormone thyroxine, which has several functions, including: (1) speeding up cell metabolism, (2) speeding up heart rate, (3) depleting fat stores, and (4) increasing motility of the gastrointestinal tract. Thyroxine is formed from iodine and tyrosine (an amino acid). When iodine is lacking in the diet, the cells of the thyroid begin to hypertrophy to compensate for the decreased production of thyroxine. The end result is a <u>goiter</u>. A goiter can also result from an overactive thyroid. In this instance, an overproduction of thyroxine (hyperthyroidism) occurs, the person is very nervous, has a high metabolic rate, and may even exhibit exophthalmos (protruding eyeballs). In addition, the thyroid gland secretes the hormone <u>calcitonin</u>, which acts as a <u>short-term</u> regulator of the blood level of calcium ion. The presence of calcitonin <u>reduces</u> the calcium level.

2-42. PARATHYROIDS

Attached to the thyroid gland, but quite small in size, are the parathyroids. The parathyroids secrete parathormone, which is primarily responsible for regulating calcium levels in the extracellular fluids (interstitial and vascular fluids). The chief cells within the parathyroid gland are thought to be the cells that elaborate parathormone. A proper level of calcium ions is needed in the circulatory system for the blood clotting mechanism to function normally. In addition, a specific level of calcium ions is required in the extracellular fluids to prevent tetany or the continuous spasmotic contraction of skeletal muscle groups. It is also thought that parathormone is responsible for promoting kidney excretion of phosphate. If the serum concentration of calcium falls below a critical point, parathormone will be secreted in large amounts and will dissolve bone to raise the calcium level in blood.

2-43. THYMUS

The thymus is located anterior to the aorta and posterior to the sternum. The thymus is probably the primary source of lymphocytes at birth, but later the lymphatic system is the chief source of lymphocytes. In the adult, cells of the thymus are thought to be involved in antibody production.

2–44. ADRENAL CORTEX

The adrenal cortex, the outer layer of each adrenal gland, secretes three types of hormones: mineralocorticoids, glucocorticoids, and androgens.

a. Mineralocorticoids, such as aldosterone, regulate electrolytes (especially sodium). Aldosterone, mentioned previously in the section on the urinary system, promotes the active reabsorption of sodium ions in the kidney tubules. This in turn decreases the reabsorption of potassium and increases the reabsorption of chloride and water.

b. Glucocorticoids, such as hydrocortisone, function to enhance resistance to physical stress. Hydrocortisone promotes both protein and fat metabolism. It affects protein metabolism by increasing the rate of transfer of amino acids from cells into the blood and interstitial fluids. The amino acids can thereby be transported to specific bodily areas where they are momentarily in demand. Hydrocortisone also mobilizes fat from fat depots in much the same manner as it mobilizes amino acids from cells. Hydrocortisone affects glucose metabolism through a process called gluconeogenesis. In this process, both proteins and lipids are converted into glucose. Glucose can then be rapidly broken down into water and carbon dioxide with the release of several adenosine triphosphate (ATP) molecules.

c. Androgens are hormones that affect male secondary sexual characteristics. The testes are the primary source of male hormones; however, the adrenal cortex also secretes minute quantities.

2-45. ADRENAL MEDULLA

The adrenal medulla is the innermost region of the adrenal gland. <u>Epinephrine</u> (Adrenalin) is the primary hormone secreted by the adrenal medulla. Epinephrine stimulates the sympathetic nervous system. Epinephrine is responsible for preparing an individual for vigorous physical and mental activity. It prepares the system for strenuous activity by (1) increasing the metabolism of all cells, (2) increasing heart rate, (3) inhibiting peristalsis in the gut, (4) initiating sweating, and (5) dilating the pupils (see Table 2−1). Epinephrine elevates the blood sugar concentration by stimulating the release of glucose from both the liver and muscle glycogen. A similar hormone released by the adrenal medulla in small amounts is <u>norepinephrine</u>, which is released in response to hypotension (low blood pressure).

2–46. PANCREAS (ISLETS OF LANGERHANS)

The pancreas is comprised mainly of pancreatic acinar (saclike) tissue that secretes enzymes for the chemical digestion of food in the small intestine. Scattered throughout pancreatic tissue, however, are small epithelial masses known as islets of Langerhans. Basically two types of cells, alpha and beta cells, are found within the islets. The beta cells secrete <u>insulin</u>, which is necessary for the transfer of sugar from extracellular fluids into cells. When an adequate level of insulin is not present in the bloodstream, excessive quantities of sugar remain in the blood, and are detected in urine. Diabetes mellitus is the name of the disease that results from failure of the pancreas to secrete adequate quantities of insulin. The alpha cells found within the islets of Langerhans secrete glucagon. Glucagon effects a rapid breakdown of glycogen to glucose in liver cells. Blood glucose levels rise after glucagon is secreted by alpha cells. Insulin and glucagon are, therefore, antagonists. Insulin effects an active cellular absorption of glucose from extracellular fluids while glucagon increases blood glucose levels.

2−47. GONADS

a. Ovaries (Female). The ovaries, located in the pelvic cavity, secrete estrogens and progesterone. Estrogens are also secreted by the adrenal cortex and during pregnancy in very large amounts by the placenta.

(1) The main function of estrogens is to promote cellular proliferation and growth of the sexual organs and other reproductive tissues. Estrogens cause the endometrium (lining of the uterus) to thicken, and they play an essential role in the regulation of the menstrual cycle. Estrogens produce the secondary sex characteristics of females: enlargement of the uterus and vagina, growth of pubic hair, development of mammary glands, development of the pelvic girdle, and deposition of fat in the mons pubis and labia majora.

(2) Progesterone is secreted by the corpus luteum and during pregnancy by the placenta. (The corpus luteum is a glandular mass formed in an ovary when a follicle discharges its ovum. If the ovum is impregnated, the corpus luteum increases in size and lasts for several months. Without pregnancy, the corpus luteum actively secretes for only about 14 days.) The function of progesterone is primarily to provide adequate nutrients for an embryo if it should begin to develop. During pregnancy, it maintains the placenta, prevents further ovulation, enlarges the breasts, and stimulates the development of the milk−secreting cells in the mammary glands.

b. **Testes (Male).** The testes, located in the scrotum, secrete testosterone. The testes of a fetus secrete testosterone to stimulate the development of the male anatomy. After birth the testes become dormant and remain so until puberty, when testosterone is secreted once again and stimulates the development of secondary male sex characteristics, including enlargement of the male sex organs, growth of facial, pubic, and chest hair, growth of the larynx to deepen the voice, and deposition of protein to increase muscularity and general body size.

2−48. THE PITUITARY GLAND (HYPOPHYSIS)

The pituitary gland lies at the base of the brain and is attached to it by a short stem. The pituitary gland is made up of an anterior and a posterior lobe.

a. **Anterior Lobe (Adenohypophysis).** The anterior lobe of the pituitary gland produces many hormones, each of which has a specific action on other endocrine glands, including the gonads, thyroid, and adrenal cortex. For this reason, the anterior lobe of the pituitary gland is sometimes called the master gland of the endocrine system. By this means, hormones of the anterior pituitary lobe control the function of other endocrine glands and influence the effects of their secretions.

b. **Posterior Lobe (Neurohypophysis).** The posterior lobe only stores hormones, one of these helps to control the excretion of water from the body; another stimulates smooth muscle contraction. Several other hormones are known to exist here.

2−49. HORMONES OF THE ANTERIOR PITUITARY

a. **Somatotropin.** Somatotropin (Growth Hormone) (GH or STH) causes growth of all tissues of the body that are capable of growing. This hormone causes both increased size of the cell itself and increased mitosis, with the development of increased numbers of cells. This hormone increases the rate of protein synthesis in all the cells of the body, decreases the rate of carbohydrate utilization, and increases the mobilization of fats and the use of fats for energy.

b. **Corticotropin .** Corticotropin (Adrenocorticotropin, ACTH) stimulates the adrenal cortex. ACTH causes the adrenal cortex to produce an increased quantity of hormones. ACTH also controls the adrenal cortex to the extent that if the pituitary gland is removed, the adrenal cortex atrophies and becomes degenerate. If fresh pituitary gland is introduced, the adrenal cortex repairs itself.

c. **Thyrotropin.**

(1) Stimulates thyroxine activity. Thyrotropin (TSH) increases the rate at which inorganic iodine is taken up by the thyroid cells from the blood. Thyrotropin further increases the rate at which thyroxine in the thyroid is released into the blood.

(2) Stimulates thyroid growth. Thyrotropin causes an increase in the size of the thyroid cells and also an increase in the number of cells.

d. **Follicle-Stimulating Hormone**

(1) Graafian follicle control. In the female, follicle-stimulating hormone(FSH) causes the proliferation of the ovarian follicular cells during growth of the Graafian follicles. These cells are also stimulated to secrete small amounts of estrogen.

(2) Induction of spermatogenesis. In the male, FSH stimulates spermatogenesis (the production of sperm).

e. **Luteinizing Hormone.** In the female, luteinizing hormone (LH), Interstitial cell-stimulating hormone (ICSH) joins with follicle-stimulating hormone to stimulate estrogen secretion. Luteinizing hormone also promotes the rupture of the follicle to release the ovum so that it may be impregnated. In the male, it stimulates the production of testosterone.

f. **Luteotropic Hormone.** In females, luteotropic hormone (LTH), Prolactin promotes the growth of breast tissue and lactation. In concert with LH, it stimulates and maintains the corpus luteum, which secretes progesterone and estrogens.

2-50. HORMONES OF THE POSTERIOR PITUITARY

a. **Luteinizing Hormone (Vasopressin).**

(1) Blood pressure. If large amounts of antidiuretic hormone(ADH) are injected into an animal, the arterial pressure rises appreciably.

(2) Renal tubule effect. This hormone increases the permeability of the collecting tubules to water. Without ADH (diabetes insipidus), a person will lose large amounts of water from the body fluids, but retain the electrolytes. In the presence of ADH, a person keeps most of the water in the body but loses more electrolytes. Luteinizing hormone keeps the body fluid diluted and a lack of this hormone concentrates the body fluids.

b. **Oxytocin.**

(1) Contraction of uterus. Oxytocin in sufficient quantity causes the uterus to contract and is therefore responsible, to a large degree, for initiating labor and birth.

(2) Milk ejection. Suckling stimulates the release of oxytocin that, in turn, starts the flow of milk.

2-51. PINEAL BODY

The pineal body is a controversial structure and considerable research is being conducted on this gland. It is thought to inhibit the onset of puberty in man because certain individuals with damaged pineals show precocious (early) development of their sexual organs. The pineal body is also thought to be important in maintaining patterns and rhythms in animals.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS. Answer the following exercises by marking the lettered response that best answers the exercise or best completes the statement or by writing the answer in the space provided.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. From the components below, select the component of blood plasma.

   a. Red blood cells.

   b. Water.

   c. White blood cells.

   d. Bacteria.

NOTE: USE THE FIGURE ON THE RIGHT TO ANSWER EXERCISES 2 AND 3.

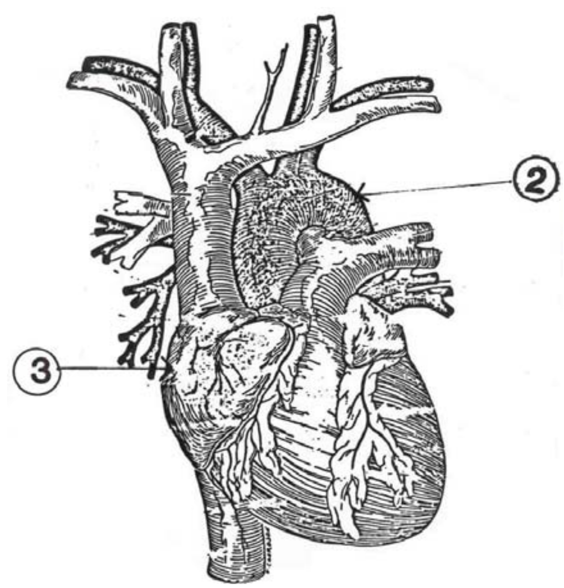
2. Select the name of the part of the heart to which arrow 2 is pointing.

   a. Pulmonary artery.

   b. Aorta.

   c. Right atrium.

   d. Inferior vena cava.



3. Select the name of the part of the heart to which arrow 3 is pointing.

   a. Left ventricle.

   b. Right ventricle.

   c. Left atrium.

   d. Right atrium.

4. From the list of functions below, select the function of the valves of the heart.

    a. Prevents air from entering the blood.

    b. Allows blood to pass from a chamber but prevents it from returning to that chamber.

    c. Prevents blood from passing through the heart.

    d. Prevents blood from flowing in the veins.

5. Select the statement that best describes the atrioventricular (AV) node.

    a. Acts as a relay station for the impulses originated by the sinoatrial (SA) node.

    b. Acts as the pacemaker of the heart.

    c. Acts as an attachment that prevents the heart from shifting in the body during periods of exercise.

    d. Controls the back-flow of blood into the different chambers of the heart.

6. From the list below, select the function of the lymphatic system.

    a. Excretes cholesterol from the body.

    b. Assists in the deamination (breakdown) of amino acids.

    c. Forms lymphocytes.

    d. Transmits nerve impulses.

7. From the components below, select the component of bile.

    a. Bile salts.

    b. Bile sugars.

    c. Bacteria.

    d. Duodenum.

8. From the functions below, select the metabolic function of the liver.

   a. Filters away bacteria.

   b. Removes clotting factors from the blood.

   c. Forms red blood cells in the elderly.

   d. Carbohydrate metabolism.

NOTE: USE THE FIGURE ON THE RIGHT TO ANSWER EXERCISES 9 AND 10.

9. Select the name of the part of the digestive system to which arrow 9 is pointing.

   a. Parotid gland.

   b. Esophagus.

   c. Pylorus.

   d. Duodenum.

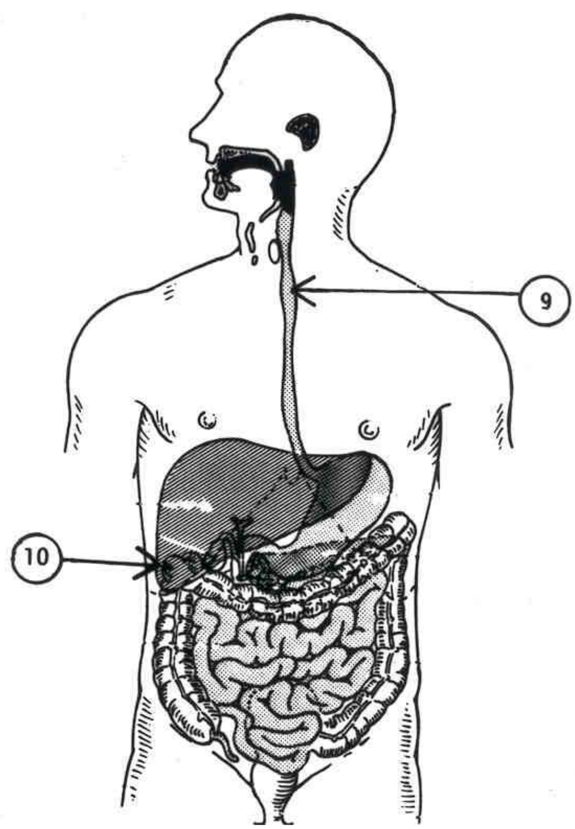
10. Select the name of the part of the digestive system to which arrow 10 is pointing.

   a. Liver.

   b. Gallbladder.

   c. Common bile duct.

   d. Cecum.



11. From the functions below, select the function of saliva.

    a. Keeps the food from becoming moist.

    b. Moistens food and makes it easier to swallow.

    c. Prevents any digestion of food until it reaches the stomach.

    d. Aids in the digestion of cellulose.

12. From the purposes below, select the purpose of trypsin.

    a. Forms proteins from amino acids.

    b. Breaks down proteins to fats.

    c. Hydrolyzes starches.

    d. Splits whole and partially digested proteins into amino acids and polypeptides.

13. From the end products of digestion below, select the end product(s) of the digestion of fats.

    a. Simple sugars.

    b. Fatty acids and glycerol.

    c. Amino acids.

    d. Monosaccharides.

14. Select, from the substances listed below, the substance primarily absorbed in the large intestine.

    a. Food.

    b. Fats.

    c. Electrolytes.

    d. Cellulose.

15. From the descriptions below, select the best description of the alveoli.

    a. A smooth tube that transports the air to the lungs.

    b. A piece of fibroelastic cartilage that lies under the tongue.

    c. The part of the respiratory system that produces sounds.

    d. Tiny, thin-walled sacs that are the site of gas transfer in the lungs.

16. From the statements below, select the statement which best describes residual volume.

    a. The extra volume of air that can be inspired over and above normal breathing.

    b. The volume of air exchanged in normal breathing.

    c. The volume of air contained in the lung after a forceful expiration.

    d. The volume of air that can be expired forcefully.

17. From the statements below, select the statement that best describes how the majority of oxygen is transported in the body.

    a. Oxygen dissolved in the blood.

    b. Oxygen transported in association with hemoglobin.

    c. Oxygen transported in association with white blood cells.

    d. Oxygen transported in plasma as the bicarbonate ion.

18. From the group of responses below, select the response which contains the divisions of the nervous system.

    1. The central nervous system.
    2. The peripheral nervous system.
    3. The autonomic nervous system.
    4. The thymus.

    a. 1 and 4.

    b. 2 and 3.

    c. 1, 2, and 3.

    d. 2, 3, and 4.

19. From the statements below, select the best description of the brain.

    a. The part of the central nervous system that consists of thecerebrum, the cerebellum, the pons, and the medulla oblongata.

    b. The smallest unit of structure of the nervous system.

    c. The organ of the body that secretes epinephrine.

    d. The organ of the body that secretes progesterone.

20. Categorize the action of "inhibited peristalsis" as a function of either the sympathetic or parasympathetic part of the autonomic nervous system.

    a. Sympathetic.

    b. Parasympathetic.

21. Categorize "slowed heart action" as a function of either the sympathetic or parasympathetic part of the autonomic nervous system.

    a. Sympathetic.

    b. Parasympathetic.

22. From the descriptions below, select the statement which best describes the thymus gland.

    a. The gland responsible for producing the hormone thyroxine.

    b. The gland responsible for producing the hormone parathormone.

    c. The gland responsible for the primary production of lymphocytes at birth.

    d. The gland responsible for the production of epinephrine.

23. From the descriptions below, select the statement which best describes the pancreas.

    a. The gland responsible for the production of testosterone.

    b. The gland responsible for the secretion of enzymes used for the chemical digestion of food in the small intestine.

    c. The gland responsible for the production of somatotropin.

    d. The gland responsible for the production of oxytocin in the body.

24. From the list below, select the function of insulin.

    a. Responsible for the transfer of sugar from extracellular fluids into cells.

    b. Responsible for the growth of sexual organs.

    c. Responsible for the production of male and female secondary sexual characteristics.

    d. Responsible for the excretion of water from the body.

25. From the list below, select the function of thyroxine.

    a. Serves as the primary producer of lymphocytes at birth.

    b. Responsible for increasing cell metabolism.

    c. Serves to enhance resistance to physical stress.

    d. Serves to inhibit the onset of puberty in males.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. b (para 2−3a)
2. b (figure 2−4)
3. d (figure 2−4)
4. b (para 2−5c)
5. a (para 2−5e(2))
6. c (para 2−6a(3))
7. a (para 2−11)
8. d (para 2−12a)
9. b (figure 2−9)
10. b (figure 2−9)
11. b (para 2−15b)
12. d (para 2−17b(1))
13. b (para 2−19c)
14. c (para 2−20c)
15. d (para 2−29i)
16. c (para 2−30d)
17. b (para 2−32)
18. c (para 2−34b)
19. a (para 2−35b)
20. a (Table 2−1)
21. b (Table 2−1)

22. c (para 2−43)

23. b (para 2−46)

24. a (para 2−46)

25. b (para 2−41)

End of Lesson 2

APPENDIX

GLOSSARY OF SELECTED MEDICAL TERMS
USED IN THE SUBCOURSE

A-1. LIMITATIONS

This appendix is added to Subcourse MD0851 in response to numerous requests of students and also to meet the needs of those students who cannot obtain the use of a medical dictionary. However, students must be aware of the limitations of this appendix. When a full and specific definition is required, consult a medical dictionary For some medical terms not included below, the student may arrive at a definition by combining the stems, prefixes, and suffixes listed.

A-2. DIACRITICAL MARKINGS

The accent mark (') is placed after the syllable to be accentuated. Accent is the emphasis or stress given to a syllable that makes it stand out from adjacent syllables. The primary or strong accent is indicated by the mark (‘). The secondary or weaker accent is indicated by the mark (").

A

Abscess (ab'ses). A collection of pus in inflamed body tissues.

Acromegaly (ak"ro-meg'ah-le). A condition in which the bones of the head hands, and feet are enlarged.

Acropathy (ak-rop'ah-the). Any disease of the limbs.

Actinomycosis (ak"ti-no-mi-ko'sis). A fungal infection of cattle and man.

Adduct (ah-dukt'). To draw or move toward the medial axis or another part of the body.

Adenitis (ad"e-ni'tis). Inflammation of a gland.

Adencarcinoma (ad"-no-kar"si-no'mah). A gland-like malignant tumor.

Adrenal (ad-re'nal). Located near the kidney.

Aerobe (a'er-ob). A microorganism that can live and grow in free oxygen.

Albino (al-bi'no). A person who lacks pigment (normal coloration) in the skin.

Albumin (al-bu'men). White of egg; a protein found in almost all animals and plants.

Allergy (al'er-je). Oversensitivity to a certain substance such as food, dust, pollen, etc.

Anabolism (ah-nab'o-lizm). A process in which food is changed into living tissue in plant or animal.

Analgesia (an"al-je'ze-ah). Absence of pain.

Anemia (ah-ne-me'ze-ah). A condition in which the red blood cells are reduced below normal.

Anesthesia (an"es-the'ze-ah). Total or partial loss of feeling or sensation.

Anesthetize (an-nes'the-tiz). To give anesthetics.

Aneurysm (an'u-rizm). A sac filled with blood and formed by enlargement of an artery or a vein.

Angiitis (an"je-I'tis). Inflammation of a blood or lymph vessel.

Anodyne (an'o-din). A medicine that relieves pain.

Anomaly (ah-nouum'ah-le). A deviation from the regular arrangement.

Anoscope (a'no-skop). An instrument for examining the anus and rectum.

Anticoagulant (an"tiko-ag'u-lant). A substance that prevents a liquid or blood from clotting.

Antipyretic (an"ti-pipret'ik). Anything that relieves or reduces fever.

Apnea (ap-ne'-ah). Temporary stopping of breathing.

Appendage (ah-pen'dij). Something added such as a tail.

Appendectomy (ap"en-dek'to-me). Surgical removal of the appendix.

Appendicitis (ah-pen"di-si'tis). Inflammation of the appendix.

Arachnoid (ah-rak'noid). The middle of three membranes covering the brain and spinal cord.

Arteriosclerosis (ar-ter"I-o-skle'ro'sis). A thickening and hardening of the arteries.

Arthralgia (ar-thral'je-ah). Pain in the joint.

Arthritis (ar-thri'tis). Inflammation of a joint.

Articular (ar-tik'u-lar). Pertaining to a joint.

Asthenia (as-the'neah). Loss of body strength and energy.

Auscultation (aws"kul-ta'shun). Listening for sounds within the body, usually with a stethoscope.

B

Bacilli (bah-sil'i). Rod shaped bacteria.

Bacteremia (bak"ter-e'me-ah). The 556presence of bacteria in the blood stream.

Bactericide (bak-ter'I-sid). Any agent that kills bacteria.

Basal (ba'sal). Forming the base; fundamental.

Basophil (bas'so-fil). A tissue or structure cell that is readily stained with basic dyes.

Benign (be-nin). Not malignant; outlook for recovery is good.

Biology (bi-ol'o-je). Science that deals with living things-plants and animals.

Biped (bi'ped). An animal with two feet.

Bronchitis (bron-ki'tis). Inflammation of the bronchial tubes.

C

Canalicular (kan"ah-lik'-u-lar). Resembling or pertaining to a narrow tubular passage.

Cardiorrhaphy (kar"de-or'ah-fe). A suturing of the heart muscle.

Catabolism (kah-tab"o-lizm). Breaking down of the body's substances by living cells into waste products.

Cephalalgia (sef"ah-lal'je-ah). Pain in the head.

Cerumen (se-roo'men). Earwax in the external ear.

Chancroid (shang'kroid). Venereal ulcer usually on the genitals.

Cholecystitis (ko"le-li-thi'ah-sis). Inflammation of the gallbladder.

Cholelithiasis (ko"le-li-thi'ah-sis). Formation of gallstones.

Chondroma (kon-dro'mah). growth of a cartilaginous tumor.

Chyle (kil). A milky fluid in the lacteals in the intestine.

Coagulation (ko-ag"u-la'shun). Formation of a clot.

Cocci (kok'si). Sphere-shaped bacterial cells.

Coccyx (kok'siks). Small bone at the lower end of the vertebral column, shaped like a cuckoo's beak.

Colitis (ko-li'tis). Inflammation of the colon.

Colostomy (ko-los'to-me). Surgical operation forming a new anal opening in the colon.

Colporrhaphy (kol-por'ah-fe). The suturing of the vagina.

Corneum (kor'ne-um). Horny layer of the skin.

Costalgia (kos-tal'je-ah). Painful ribs.

Cretinism (kre'tin-izm). Congenital deficiency of thyroid secretion resulting in abnormal physical and mental development.

Cryptogenic (krip"to-jen'ik). Of unknown or obscure origin usually said of a disease.

Cryptorchidism (krip-tor'ki-dizm). Failure of the testes to enter the scrotum.

Cutaneous (ku-ta'ne-us). Of the skin.

Cuticle (ku'te-kl). The outermost layer of skin.

Cyanosis (si"ah-no'sis). A bluish discoloration of the skin.

Cytology (si-tol'o-je). The scientific study of cells.

D

Deamination (de-am"I-na'shun). Removal of the amino group, $-NH_2$, from a compound.

Dehydrate (de-hi'drat). To remove water from.

Dermatology (der"mah-tol'o-je). The study of diseases of the skin.

Dermatophytosis (der'mah-to-fi-to'sis). Fungal infection of the skin.

Diarrhea (di"ah-re'ah). Excessive frequency and liquidity of bowel movements.

Diuretic (di"u-ret'ik). An agent that promotes the excretion of urine.

Dyslexia (dis-lex'se-ah). A disturbance in the ability to read.

Dysmenorrhea (dis"men-o-re'ah). Painful menstruation.

Dysphagia (dis-fa'je-ah). Disturbance in swallowing.

Dysuria (dis-u're-ah). Pain during urination.

E

Ectoderm (ek'to-derm). The outer layer of cells of the embryo.

Edema (e-de'mah). Accumulation of fluid in the cells and tissues.

Efferent (ef'er-ent). Carrying away from a center as an impulse being carried away from a nerve center.

Electrocardiogram (e-lek"tro-kar'de-o-gram). A graphic tracing of the electrical impulses of the heart.

Encephalitis (en"sef-ah-li'tis). Inflammation of the brain.

Endemic (en-dem'ik). Prevalent in a certain locality.

Endocarditis (en"do-kar-di'tis). Inflammation of the lining of the heart.

Endocrine (en"do-krin). Pertaining to a gland or organ secreting internally.

Endoderm (en"do-derm). The innermost layer of cells of the embryo.

Endoscope (en"do-skop). Instrument to examine the inside of a body part.

Enteritis (en"ter-i'tis). Inflammation of the intestine.

Eosinophil (e"o-sin'o-fil). A cell readily stained by eosin.

Epidemic (ep"i-dem'ik). Occurring widely and spreading rapidly.

Epilepsy (ep'i-lep"se). A dosease of the nervous system causing involuntary muscle movements.

Epithelial (ep"i-the'le-al). Tissue that covers the external and internal surfaces of the body.

Erythrocyte (e-rith'ro-sit). Red blood cell.

Esophagus (e-sof'ah-gus). The tube connecting the pharynx and the stomach.

Excise (ek-siz'). To cut.

Extracellular (eks"trah-sel'ular). Outside of the cell

F

Familial (fah-mil'e-al). Pertaining to members of the same family.

Fascia (fash'e-ah. A layer of tissue covering or supporting muscles or organs.

Febrile (feb'ril). Pertaining to fever.

Femur (fe’mur). The thigh bone

Fibroma (fi-bro’mah). A tumor composed of fibrous tissue.

Fibrosarcoma (fi”bro-sar-ko’mah). A malignant tumor composed of fibrous tissue.

Fissure (fish’ur). A groove between two parts.

Fluoroscopy (floo”or-os’ko-pe). An examination of internal structures of the body by viewing a screen through which x-rays are directed.

G

Gastritis (gas-tri’tis). Inflammation of the stomach.

Genetics (je-net’iks). The study of heredity.

Glossitis (glos-si’tis). Inflammation of the tongue.

Glucosuria (gloo”ko-su’re-ah). Presence of sugar in the urine.

Gonorrhea (gon”o-re’ah). A contagious venereal disease.

Granuloma inguinal (gran”u-lo’mah ing’gwi-nal). Venereal disease characterized by ulcerations of the skin of the groin and genitalia.

Gynecology (jin”e-kol’o-je). The Study of women’s diseases especially the genital tract.

H

Helminthias (hel”min-thi’ah-sis). An infection of worms in the body.

Hematology (hem”ah-tol”o-je). The study of blood.

Hemiplegia (hem”e-ple”je-ah). Paralysis of one side of the body.

Hemoglobin (he”mo-glo’bin). Red pigment of the erythrocytes (red blood cells).

Hemolysis (he-mol’i-sis). Liberation of hemoglobin into the surrounding fluid.

Hemophilia (he”mo-fil’e-ah). A hereditary condition causing prolonged bleeding from slow clotting of blood.

Hemorrhage (hem’or-ij). Copious bleeding.

Hepatitis (hep"ah-ti'tis). Inflammation of the liver.

Herniorrhaphy (her"ne-or'ah-fe). Suture of a hernia.

Histology (his-tol'o-je). The study of tissues.

Hydrarthrosis (hi"drar-thro'sis). A condition of watery fluid collected in the cavity of a joint.

Hyperemia (hi"per-e'me-ah). Excessive blood in a body part.

Hyperesthesia (hi"per-es-the'ze-ah). An abnormal sensitivity.

Hypertension (hi"per-ten'shun). Abnormally high blood pressure.

Hypotension (hi"po-ten'shun). Lowered blood pressure.

Hysterectomy (his"ter-ek'to-me). Surgical cutting out of the uterus.

I

Iatrogenic (i"at-ro-jeni'ik). Pertaining to a patient's condition as a result of treatment by a medical officer.

Icterus (ik'ter-us). Condition of skin turning yellow.

Idiopathic (id"e-o-path'ik). Of unknown causes.

Ileitis (il"e-I'tis). Inflammation of the distal part of the small intestine.

Iliac (il'e-ak). Pertaining to the superior portion of the hip bone.

Integumentary (in-teg"u-men'tar-e). Composed of the skin.

Intercostal (in"ter-kos'tal). Between the ribs.

Intravenous (in"trah-ve'nus). Inside a vein.

Intussusception (in"tus-sus-sep'shun). A condition in which one section of the intestine telescopes into another section.

Ischium (is'ke-um). The lower back part of the hip bone.

Isotope (i'so-top). A chemical element having the same atomic number as another but a different atomic mass.

J

K

Keratosis (ker”ah-to’sis). Horny growth of the skin.

L

Leiomyoma (li”o-mi’o’mah). A benign tumor originated from smooth muscle.

Leptomeninges (lep”to-me-nin’jez). The pia-arachnoid of the brain and spinal cord.

Lesion (le”zhun). Any injured tissue.

Leukemia (lo͞o-ke’me-ah). A disease of the blood with abnormal increase in white blood cells.

Leukocyte (loo”ko-der’mah). Lack of pigmentation in the skin.

Leukopenia (loo”ko-pe’ne-ah). A reduction in the normal amount of whit blood cells.

Lipid (lip’id). Organic substances such as fats that are insoluble in water but soluble in alcohol.

Lipoma (lip-o’mah). A tumor of fatty tissue.

Lymphangitis (lim”fan-ji’tis). Inflammationof lymphatic vessels.

M

Macrodactyly (mak”ro-dak’ti-le). Abnormally large fingers and toes.

Malady (mal’ah-de). A disease or illness.

Malignant (mah-lig’nant). A tendency to worsen and cause death.

Malnutrition (mal”noo-trish’un). Undernourishment.

Mastitis (mas-ti’tis). Inflammation of the breast or mammary gland.

Megacolon (meg’ah-ko’lon). Abnormally large colon.

Mentrual (men’stroo-al). Pertaining to the monthly flow of blood from the uterus of women.

Mesoderm (mes'o-derm). The middle germ layer of an embryo.

Metabolism (me-tab'o-lizm). Chemical and physical processes in living organisms and cells.

Metastasis (me-tas'tah-sis). Spread of disease from one part or organ of the body to another.

Metrorrhagia (me"tro-ra'je-ah). Bleeding from the uterus.

Microscopic (mi"kro-skop'ik). Pertaining to or visible only by the aid of the microscope.

Monocyte (mon'o-sit). A large white blood cell.

Morphology (mor-fol'o-je). The science of forms and structure of animals and plants.

Mucocutaneous. (mu"ko-ku-ta'ne-us). Pertaining to the mucous membrane and the skin.

Musculoskeletal (mus"ku-lo-skel'e-tal). Comprising the muscles and the skeleton.

Mycosis (mi"ko-sis). A disease caused by fungus.

Myocardium (mi"o-kar'de-um). Muscle of the heart.

Myositis (mi"o-si'tis). Inflammation of a voluntary muscle.

Myxedema (mik"se-de'mah). A disease characterized by a drying and thickening or swelling of the skin.

N

Narcolepsy (nar'ko-lep"se). Condition characterized by uncontrollable desire for sleep.

Narcotic (nar'kot'ik). An agentproducing insensibility.

Nasopharynx (na"zo-far'inks). Part of the pharynx above the level of the soft palate.

Necropsy (nek'rop-se). Examination of a body after death; autopsy.

Necrotic (ne-krot'ik). Pertaining to death of tissue.

Neonatal (ne"o-na'tal). Pertaining to the first four weeks after birth.

Nephritis (ne-fri'tis). Inflammation of the kidney.

Nephrolithiasis (nef"ro-li-thi'ah-sis). Condition characterized by presence of stones in the kidney.

Neppropexy (nef'ro-pek"se). Suspension of a floating kidney.

Neuralgia (noo-ral'je-ah). Pain in one or more nerves.

Neurology (noo-rol'o-je). Study of the nervous system.

Neuropsychiatry (noo"ro-si"ki'ah-tre). A branch of medicine including neurology and psychiatry.

Neurosis (noo-ro'sis). A disorder of the nervous system.

Nocturia (nok-tu're-ah). Excessive urination at night.

Nuchal (nu'kal). Pertaining to the back of the neck.

O

Oculomotor (ok"u-lo-mo'tor). Pertaining to the movement of the eyeball.

Oculus (ok'u-lus). The eye.

Onychomcosis (on"i-ko-mi-ko'sis). A disease of the fingernails and toenails.

Oophorectomy (o"of-o-rek'to-me). Surgical removal of one or more ovaries.

Oophoritis (o"of-o-ri'tis). Inflammation of an ovary.

Ophthalmology (of"thal-mol'o-je). The branch of medicine concerning the eye.

Orchitis (or-ki'tis). Inflammation of a testis.

Oropharynx (o"ro-far'inks). Part of the pharynx between the soft palate and the upper edge of the epiglottis.

Orthodontist (or"tho-don'tist). A dentist who specializes in prevention and correction of teeth with facial problems.

Orthopedics (or"tho-pe'diks). Pertaining to that branch of surgery that restores functions of the skeletal system.

Osseous (os'e-us). Bony.

Ossicle (os'si-kal). A small bone.

Osteology (os"te-ol'o-je). The scientific study of bones.

Osteomyelitis (os"te-o-mi"e-li'tis). Inflammation of bone marrow.

Osteosarcoma (os"te-o-sar-ko'mah). Tumor of bone.

Otologist (o-tol'o-jist). A specialist in medicine dealing with the ear and its diseases.

Otoscope (o'to-skop). Instrument of examining the ear.

P

Palate (pal'at). A partition that separates the nasal and oral cavities.

Pancarditis (pan"kar-di'tis). General inflammation of the entire heart.

Panhypopituitarism (pan-hi"po-pi'tu'i'tar-izm). Insufficient secretion of the anterior pituitary gland.

Papilla (pah-pil'lah). A small nipplelike projection of tissue.

Parietal (pah-ri'e-tal). Pertaining to the walls of a hollow organ or cavity.

Paronychia (par"o-nik'e-ah). Inflammation of the tissue surrounding the fingernail.

Pathogenesis (path"o-jen'e-sis). Development of disease.

Pediatrics (pe"de-at'riks). The branch of medicine dealing with diseases of children.

Pleurodynia (ploor"o-din'e-ah). Pain in the intercostals muscles.

Pneumothorax (noo"mo-tho'raks). The presence of air or gas in the pleural cavity.

Polycythemia (pol"e-si-the'me-ah). Excess number of red blood cells in the blood.

Polymorphic (pol"e-mor'fik). Occurring in several forms.

Polyuria (pol"e--u're-ah). Excessive urination.

Post mortem (post mor'tem). After death

Prenatal (pre-na'tal). Happening before birth

Pyelonephritis (pi"e-lo-ne-fri'tis). Inflammation of the kidney and its pelvis

Pyoderma (pi"o-der'mah). A pus-forming skin disease.

Pyogenic (pi"o-jen'ik). Pus-forming.

Pyrexia (pi-rek'se-ah). To be feverish.

Pyrogenic (pi"ro-jen'ik). Producing heat or fever.

Q

R

Renal (re'nal). Pertaining to the kidney.

Retrosternal (re"tro-ster'nal). Situated behind the breast bone.

Rhinitis (ri-ni'tis). Inflammation of the mucous membrane of the nose.

Rhinoplasty (ri'no-plas"te). Plastic surgery of the nose.

Rickettsiae (rik-et'se-e). Organism of the genus Rickettsia; small intracellular endoparasites.

S

Sacroiliac (sa"kro-il'e-ak). Usually pertaining to the joint between the sacrum and ileum.

Salpingitis (sal"pin-ji'tis). Inflammation of the uterine tube or the auditory tube.

Sclera (skle'rah). The tough, white fibrous membrane covering most of the eyeball.

Semilunar (sem"e-lo̅o'nar). Shaped like a half-moon.

Serous (se'rus). Containing serum.

Sinusitis (si"nus-i'tis). Inflammation of the air cavities in the head.

Splanchnology (splank-nol'o-je). The branch of medical sciences dealing with the study of the viscera.

Stasis (sta'sis). Stoppage of the flow of blood.

Stenosis (ste-no'sis). Narrowing or stricture of a duct or canal.

Stoma (sto’mah). Any opening on a free surface; mouth-like opening.

Subdiaphragmatic (sub”di-ah-frag-mat’ik). Situated under the diaphragm.

Symptomatic (simp”to-mat’ik). Pertaining to a symptom.

Syncope (sin’ko-pe). Fainting; temporary loss of consciousness.

Synovial (si-no’ve-al). Pertaining to the secretion of fluid in joint cavities.

T

Thoracolumbar (tho”rah-ko-lum’bar). Pertaining to the thoracic and lumbar portions of the spine.

Thoracotomy (tho”rah-kot’o-me). Surgical incision of the wall of the chest.

Thrombosis (throm-bo’sis). A formation of a plug or blood clot in a blood vessel or in the heart.

Tracheotomy (tra”ke-ot’o-me). Incision of the trachea through the skin muscle of the neck.

Tsutsugamushi (so̅o̅t”so̅o̅-gah-mo̅o̅sh’e). Scrub typhus.

Tuberculosis (to̅o̅-ber”ku-lo’sis). An infectious disease especially of the lungs.

U

Urethra (u-re’thrah). The canal through which urine is discharged from the bladder to the outside.

Uterus (u’ter-us). Womb of a female.

V

Vascular (vas’ku-lar). Pertaining to vessels

Vasoconstriction (vas”o-kon-strik’shun). The narrowing of the blood vessels.

Vertigo (ver’ti-go). Sensation of movement.

Vesical (ves’I-kal). Pertaining to the urinary bladder.

Vesicorectal (ves”I-ko-rek’tal). Pertaining to the urinary bladder and rectum.

Viscera (vis'er-ah). The large interior organs located in the cavities of the body.

Volvulus (vol'vu-lus). Intestinal obstruction caused by twisting of the bowel.

W

X

Y

Z

End of Appendix