Basic Concepts and Organ Systems

Lesson 1

ASSIGNMENT 1: INTRODUCTION TO THE STRUCTURAL UNITS

Read Assignment 1 in this study guide. Then read Chapter 1, pages 1–11, in your textbook, *Body Structures & Functions.* There are no corresponding sections in the CD-ROM for this assignment.

The Sciences of Anatomy and Physiology

It's important to define the sciences of anatomy and physiology to appreciate the scope of this course. Anatomy and physiology are technically separate sciences. You may choose to study both areas as separate courses. But for practical purposes, the two fields are closely associated. *Anatomy* describes the shape and structure of the body and its parts. *Physiology* deals with how each body part functions and how all body parts form the complete body. This course presents the anatomy and physiology of each body system together as an integrated unit.

There are several branches of anatomy that correspond to different approaches in studying the structure of the human body. The assignments in this course will include elements of *gross anatomy, microscopic anatomy, developmental anatomy,* and *systematic anatomy;* however, *comparative anatomy* won't be covered.

General Anatomical Terms

Before delving into the internal anatomy of the human body, you need to understand the basic terms applicable to the body as a whole. Study Figure 1-1 in your textbook. The man is standing in the *anatomical position.* This position is defined very specifically so that anyone in the world can use this framework when describing anatomical relationships. Pay special attention to the designation of right and left. Right refers to the subject's right side, not what's on the right side of the viewer. It might be easier to learn these anatomical terms by using your own body as a model. Notice how your hand is *distal* to your elbow, and how your nose is *medial* to your eyes. The dashed lines in Figures 1-1 and 1-2 delineate the various planes and sections of the body, which are also described on page 7 of your textbook in the "Medical Terminology" box. These planes are particularly useful in the field of radiology because cross-sectional images of the body are frequently obtained.

Figure 1-3 and pages 4–5 of your textbook describe the various body cavities, starting from the largest cavities and progressing to the smaller cavities. Knowledge of these cavities is important in understanding the targets of radiological imaging tests. Also, many disease processes or symptoms are specified in terms of body cavities. Pain in the *thoracic cavity,* or chest, is a common symptom that brings people to the emergency room for help. Abdominal pain signifies pain that feels like it originates from the *abdominal cavity.* Figure 1-4 depicts the nine regions of the abdomen that are useful for describing the exact location of abdominal pain or symptoms.

Functions and Processes within the Body

Table 1-1 in your textbook lists the definition of major life functions. Each life function is associated with a body system. The function of movement is performed by the muscle system, whereas secretion is performed by the endocrine system. You should focus on the body systems, because these terms form the basis of the disease categories that are found in patient medical records. For example, a stomach ulcer will be categorized under the digestive system. Study Table 1-1 carefully so that you can define and describe the life functions and body systems. For further illustration, listed next are selected examples of life functions and body systems.

- Movement/Muscle System—Your arm muscles contract to move your arm.
- Ingestion/Digestive System—You eat and swallow food.
- Digestion/Digestive System—Your stomach, intestines, and other organs digest your food into smaller particles.
- Transport/Circulatory System—Your heart pumps blood through the blood vessels to supply oxygen to cells throughout the body. The cells use the oxygen and produce waste products, which are carried back to the heart by the blood vessels.
- Respiration/Respiratory System—The cells in your body use food molecules, such as carbohydrates, to produce energy, water, and the waste product carbon dioxide. Note that this type of respiration is *cellular respiration,* not the type of respiration that occurs when you breathe with your lungs.
- Secretion/Endocrine System—Your thyroid gland *secretes* thyroid hormones to regulate various functions of the body.
- Excretion/Urinary System—Your kidneys filter the bloodstream and remove waste and excess molecules. These are removed from your body when you urinate.

Even though you don't need to be concerned with exactly how a single cell develops into a fully formed human being, it's important to understand that our bodies are organized in a complex hierarchy. Cells form tissues, and these tissues make up organs. Finally, the organs interact to form organ systems. Diseases and conditions are often described in terms of organ systems or organs (e.g., stomach, lungs). Note that the organ systems are essentially the same as the body systems listed in Table 1-1; this distinction is merely one of terminology. Thus, you should focus on learning the definitions and descriptions of the various organ systems.

Next, move on to the terms describing the general body processes in the last section of Chapter 1. These processes are simple to understand in the context of nutrition and food. The food you eat usually contains a mixture of protein, carbohydrates, and fats. These are basic building blocks for the body. After your body digests the food, it uses these building blocks to construct muscle tissue, deposit fat underneath your skin, and store carbohydrate energy. This process is called *anabolism.* Anabolism requires energy, much like the process of erecting a house from lumber requires the energy of the construction workers. *Catabolism* is the opposite process, in which a complex substance is broken down into its smaller components. For example, if you exercise for a sufficient amount of time, your body will begin "burning fat" (i.e., breaking down fat into smaller molecules to release the necessary energy required for continued exercise). *Metabolism* is the sum of the chemical reactions of anabolism and catabolism.

Scan through the list of medical terms on page 7. You should recognize these words from the text you've just read. If a word is unfamiliar, take note of the definition in this list and also refer back to the text where the word was first introduced.

Now, review the material you've studied here. Once you feel you understand the material, complete *Self-Check 1.* Then check your answers with those provided in the study guide. When you're sure you completely understand the materials from Assignment 1, move on to Assignment 2.

Self-Check 1

At the end of each section of *Anatomy and Physiology 1*, you'll be asked to pause and check your understanding of what you've just read by completing a "Self-Check" exercise. Answering these questions will help you review what you've studied so far. Please complete *Self-Check 1* now.

Answer Review Questions 1, 4, 6, 8, and 10 on pages 8–9 of your textbook.

Check your answers with those on page 119.

ASSIGNMENT 2: CHEMISTRY OF LIVING THINGS

Read Assignment 2 in this study guide. Then read Chapter 2, pages 12–27, in your textbook, *Body Structures & Functions*. There are no corresponding sections in the CD-ROM for this assignment.

This assignment will introduce you to the simplest particles that make up the human body. These particles form the fabric with which the body is constructed. The information in this assignment can be applied to the whole body and thus is important to comprehend early in the course.

Basic Building Blocks

The concepts in this assignment fall within the realm of chemistry. Chemical reactions occur within your body on a continual basis. Even the smallest action, such as turning a page in this study guide, requires an unimaginably large number of chemical reactions. These reactions occur within the cells and tissues of your body. As defined in your textbook, the specialized study of chemical reactions in living things is *biochemistry,* which is a field within chemistry based on the same principles.

Read the definitions of *matter* and *energy*. It's important to understand how matter and energy are related. Application of energy can change the structure or arrangement of matter. This is easy to see in the life cycle of a tree. The sun's energy allows the structure of the tree to change (i.e., grow taller). When a lumberjack chops down the tree, his swinging ax imparts energy to the tree and thus causes another change in structure. But the converse is also true—changes in the structure or arrangement of matter can release energy. This stored-up energy is called *potential energy;* a good example of this type of energy is food. A banana (i.e., matter) contains potential energy, representing the energy required for the growth of the banana. After you eat and digest the banana, its structure is changed, thus releasing the energy for your body to use.

In pages 13–16 of your textbook, *atoms, elements, compounds,* and *molecules* are described in terms of a structural hierarchy. The examples of water and salt in the textbook are helpful in understanding this hierarchy. Water exists as molecules. Each molecule of water is constructed of two atoms of hydrogen (H) and one atom of oxygen (O). Thus, water is often called H_2O. A water molecule is the smallest possible unit of water possible. No water exists if the H and O are separated. Likewise, an atom of hydrogen is the smallest unit of hydrogen. Further division into smaller particles of hydrogen isn't possible. An element is a combination of identical atoms. Review the examples of some elements given in Table 2-1. The smallest unit for an element is the atom. For example, you could theoretically divide a bar of pure iron into countless atoms of iron. Any further division would not only require enormous energy, but would also reduce the iron atom into non-iron particles. Water is a compound, because each water molecule consists of more than one distinct element. In like manner, table salt is a compound of sodium and chloride. *Inorganic compounds* are compounds that don't contain the element carbon, with the few exceptions noted on page 16 of the textbook.

Read the "Medical Highlight" section on pages 14–15 of your textbook. This material explains how the science behind atoms, ions, and isotopes is applied to the field of medical imaging. Therefore, knowledge of chemistry isn't merely academic for people in the medical field. It can lead to the development of new technology that can improve health care for everybody.

Organic Compounds

Organic compounds, which contain carbon along with other elements, can be very complex. Organic compounds represent the basic building materials of the body. You're probably familiar with some organic compounds. The main types are *carbohydrates, lipids* (i.e., fats), *proteins,* and *nucleic acids* (genetic material). Read about these compounds on pages 17–20 in your textbook. You'll see that the phrase "you are what you eat" is literally true. The average diet contains a mixture of carbohydrates, lipids, and proteins. Your body digests and absorbs these compounds to build new tissue, repair damaged or old tissue, and store energy.

Carbohydrates are often called "sugars." But this doesn't mean that all carbohydrates are the table sugar you might put in your coffee. Carbohydrates come in many different forms, each with a different name. The three major types of carbohydrates are differentiated by the number of molecules in each compound. Help yourself remember the three main carbohydrate types by noting their prefixes. [Mon/o] means one. Thus, a monosaccharide sugar exists as a single molecule. [Di-] means two, and [poly-] means many. Study the examples of monosaccharides and disaccharides in Table 2-2 on page 18 of the textbook. The main purpose of carbohydrates is to provide energy for daily life. Some of the energy comes from processing carbohydrates from your food, whereas some energy comes from the carbohydrates stored in the liver and other organs.

Lipids serve many different functions in your body. Certain types of lipids are used for constructing cell membranes. Other lipids form the backbone for hormones. Lipids represent a potent source of energy. However, in most situations, your body burns carbohydrates before lipids. Although many people view fat as an undesirable substance, your body wouldn't function properly without a modest amount of this substance.

Proteins are the major building blocks of the body. Skin, muscle, internal organs, hair, fingernails, and certain parts of the skeletal system are chiefly made up of proteins. All proteins are composed of complex combinations of *amino acids.* When you eat protein-containing foods (e.g., meat, eggs, cheese, beans), your body breaks down these proteins into amino acids. Then the amino acids are recombined and reassembled into the specialized proteins your body needs. Familiarize yourself with the examples of essential amino acids in Table 2-3 on page 19 of your textbook. Your body can't make these amino acids, which are *essential* in the sense that it's vital for you to obtain these amino acids from food. The other amino acids are nonessential, because your body can generate them.

The last group of major organic compounds is represented by nucleic acids. *DNA,* or deoxyribonucleic acid, and *RNA,* or ribonucleic acid, are the two main types of nucleic acids. DNA is the genetic material in each cell that determines the structure and function of the cell. Study Figures 2-2 and 2-3 in your textbook. Imagine a *nucleotide,* such as the one in Figure 2-2, paired up with a complementary nucleotide. Now imagine thousands and thousands of these pairs, stacked up on each other, and then twisted around into a corkscrew formation. It's easy to see why this DNA structure is called a "twisted ladder." Note that RNA molecules come in many different forms. RNA "translates" the instructions found in DNA into actual production of proteins.

Read pages 20–23 on acids, bases, salts, and the pH scale. The chemistry of acids and bases is complex. Although entire books have been written on this subject, you need to understand only the simplest concepts for this course. Perhaps you'll recognize some substances listed in Tables 2-5 and 2-6 as acids or bases. When an acid combines with a base, a *neutralization reaction* occurs, as depicted in Figure 2-4. The pH of a substance is a single number that signifies whether the substance is *acidic* or *basic* (Figure 2-5). Certain fluids in your body are acidic, such as stomach acid, whereas others are basic, such as digestive juices from the pancreas. The pH of your blood should be 7.4. Any significant deviation from this pH may indicate that some illness or process is upsetting the acid-base balance of your body. Frequently, physicians will order laboratory tests to measure the pH in a patient's blood.

The concept of *homeostasis* is related to acid-base balance but is also broader. Homeostasis is the general balance of systems within your body. In perfect health, your homeostasis is maintained. Your ability to maintain homeostasis is vital to preserving good health. Infection, injury, and chronic disease can disrupt your homeostasis.

Now, review the material you've studied here. Once you feel you understand the material, complete *Self-Check 2*. Then check your answers with those provided in the study guide. When you're sure you completely understand the materials from Assignment 2, move on to Assignment 3.

Self-Check 2

Reinforce what you've just learned by answering Review Questions 1, 3, 6, 8, and 9 on pages 24–25 of your textbook.

Check your answers with those on page 119.

ASSIGNMENT 3: CELLS

Read Assignment 3 in this study guide. Then read Chapter 3, pages 28–49, in your textbook, *Body Structures & Functions*. There are no corresponding sections in the CD-ROM for this assignment.

You're now going to learn about the *cell*, the simplest of all living things. Yet it's remarkably sophisticated. The most advanced computer in the world can't match the complexity of a single cell. Indeed, you could devote an entire career to studying cells. In this assignment, you'll learn about the basic characteristics and functions of cells as well as illnesses caused by cell disorders. Many concepts regarding the cell are best communicated visually, so pay close attention to the textbook's figures.

Cells are tiny, microscopic living units. Your body has a countless number of cells—muscle cells, brain cells, skin cells, and so on. Each cell has a life cycle. It's born, performs functions, and then dies. But cells aren't independent. Each cell contributes to the healthy functioning of your body, and each cell depends on other cells.

The Cell and Its Parts

Read about the *cell membrane, nucleus,* and *cytoplasm* on pages 29–31 of your textbook. Notice that proteins and lipids make up the cell membrane. These are examples of organic compounds that were described in the last assignment. Think of the nucleus as the brain of the cell, coordinating all the various activities that occur inside. The nucleus contains another organic compound, namely DNA, which represents the genetic blueprint of the cell. Study Figure 3-1 on page 30 of the textbook. Notice how the cell membrane encloses the entire cell, and the *nuclear membrane* encloses the nucleus. The *endoplasmic reticulum,* discussed later in the textbook, is continuous with the nuclear membrane. One or more smaller nucleoli lay within the nucleus.

The next section discusses the cytoplasm and the major cellular structures, or organelles, which carry out specific functions within the cell. As you read pages 31–32, refer to Table 3-2 for a concise summary of the *organelles.* Also refer back to Figure 3-1 to correlate the text with illustrations of the structures. The information here is complex and may be difficult to grasp at first. Let's consider a concrete example of how these organelles might work together to produce a protein.

The first step in protein synthesis begins with nuclear DNA. The DNA sets the whole process in motion by providing the genetic instructions for constructing the protein. Messenger RNA molecules carry instructions from the DNA in the nucleus to the *ribosomes* in the cytoplasm. The transfer RNA and ribosomal RNA molecules assemble the protein from amino acids. This process occurs in the ribosomes. The ribosomes themselves are arranged along the *rough endoplasmic reticulum* (see Figure 3-1 in the textbook).

The protein passes through the *Golgi apparatus,* where it might be combined with carbohydrates. If the protein is destined to be sent outside the cell, it will pass through the cell membrane via a *pinocytic vesicle. Mitochondria* provide energy in the form of *adenosine triphosphate (ATP)* to fuel the whole process.

Note that the prefix [cyto-] and the suffix [-cyte] refer to cells. The cytoplasm is the plasm (i.e., formative substance) inside cells. The *cytoskeleton* is the skeleton of cells. This suffix can also be applied to types of cells. A *myocyte* is a muscle cell (myo = muscle), and a *hepatocyte* is a liver cell (hepato = liver). Remember to use these word components as you learn about body systems in later assignments.

Cell Division

In the process of cell division, the contents of a cell—including the DNA and membrane—are divided between two new daughter cells. This section briefly touches upon *meiosis,* or cell division for the purposes of reproduction, but mainly focuses on *mitosis,* or cell division for growth and maintenance of your body. Most cells in your body have 46 chromosomes each. A woman's eggs or a man's sperm cells undergo a specific type of cell division called meiosis so that each cell ends up with half of the 46 chromosomes (i.e., 23 chromosomes). These specialized cells are called *gametes* (i.e., sex cells). During the process of reproduction, an egg and sperm combine to form a single cell called the *zygote.* A zygote is the single cell at the very earliest stage of human development. This zygote, with 23 chromosomes from the egg and 23 from the sperm, has a total of 46 chromosomes.

From this stage forward, cell division occurs in the form of mitosis. At the end of mitosis, each daughter cell still has 46 chromosomes, which is the same number that the original cell that divided had. The zygote undergoes mitosis to divide into two daughter cells, then four, then eight, and so on, until an embryo is formed. The embryo then becomes a fetus, which becomes a newborn baby. Mitosis occurs even as the baby grows up into adulthood. Read about the specific stages of mitosis on pages 33–35 in the textbook. A key concept is that during *interphase,* or phase 1, the DNA of the cell is replicated. Thus, for a brief time during mitosis, the cell contains double the "usual amount" of DNA in the form of chromosomes. When cell division is completed, the two daughter cells have the usual amount of DNA packaged into 46 chromosomes.

Figure 3-3 is a good illustration of the process of mitosis. Imagine looking into a microscope and watching a cell proceed through the stages of mitosis depicted in the figure. Now, imagine that process occurring on a continual basis within your own body. For example, your red blood cells are constantly being recycled. As you'll learn later in the second portion of this course, each red blood cell lives only approximately 120 days. The cells in your bone marrow replenish this supply by undergoing mitosis. If mitosis didn't occur at the normal rate, there wouldn't be enough red blood cells circulating in your body. As you'll see later in this assignment, uncontrolled mitosis can lead to an overproduction of cells known as cancer. You can also appreciate the importance of mitosis if you've ever donated blood. After donating blood, you aren't supposed to donate again for several weeks to allow your bone marrow to restock the supply of red blood cells through mitosis. Read the "Medical Highlight" section on textbook pages 35 and 36 regarding *stem cell research.* The issues surrounding stem cell research have generated controversy on ethical grounds, but no matter how you feel about it, you should know the general purpose and principles of stem cell research.

Other Cellular Processes

Although each cell is a living unit, it can't thrive in isolation. Cells are constantly sending forth proteins and accepting them from their immediate environment. *Electrolytes* also pass through the cellular membrane in both directions. Think of the cell membrane as a living, dynamic membrane designed to retain certain particles and allow other particles to pass through. As you learned on page 29 of the textbook, the cell membrane is composed of lipids and proteins in a double layer. This remarkable double layer allows the cell to keep water molecules inside the cell even as other tiny particles pass in and out. The main processes through which the cell regulates passage of particles are *diffusion, osmosis, filtration, active transport, phagocytosis,* and *pinocytosis.* These processes are discussed on pages 36–40 of your textbook.

The most important principle to remember about diffusion is in the first paragraph of page 37 of the textbook. See Figure 3-4 as well. Molecules move from an area of higher concentration to an area of lower concentration. Picture schoolchildren being released for recess. They pour out of the classroom, where they were highly concentrated in a small space, and rapidly spread out to cover the entire playground. In the human body, particles diffuse across cell membranes, either into or out of the cell. But they still diffuse from areas of high concentration to areas of low concentration.

Osmosis is similar to but subtly different from diffusion. Although any type of particle (i.e., solid, liquid, or gas) can diffuse, only water or particles dissolved in water can undergo osmosis, a process that by definition occurs across a membrane. See Figure 3-5 for a good example of osmosis. *Osmotic pressure* is a very important concept to understand. As you read the explanation on page 38 of the textbook, remember that the driving force behind osmotic pressure is the fact that water molecules tend to diffuse from high concentrations to low concentrations. A solution with a high concentration of sodium molecules has a relatively low concentration of water molecules, because there's "less room" for the water molecules. This solution is *hypertonic* ([hyper-] = more) compared with the inside of a red blood cell because it contains more sodium particles. As the example in Figure 3-6 depicts, when a red blood cell is placed in this type of solution, water molecules will move from the area of higher concentration (i.e., inside the cell) to the area with lower concentration (i.e., the hypertonic solution around the cell). At the same time, sodium will also move from the high-concentration area (i.e., the hypertonic solution) to the lower-concentration area (i.e., inside the cell). However, the net result is that as water leaves the cell, the cell shrinks in size.

Filtration, like osmosis, occurs across a *semipermeable membrane.* But in this process, the driving factor is force rather than concentration. In Figure 3-7, the force of gravity pulls water molecules and small particles through the filtering membrane, whereas larger particles don't pass through.

It's similar to draining a pot of spaghetti with a strainer. The water passes through while the noodles stay behind. As explained in the text and figure, this process occurs on a continual basis in your kidneys.

The processes of diffusion, osmosis, and filtration are types of *passive transport* because they don't require input of energy. But sometimes cells need to move particles across the membrane, either into or out of the cell, through different methods that do require energy. Therefore, if a cell needs a certain electrolyte, it might use the process of active transport to move the protein from outside the cell to inside the cell, regardless of relative concentrations of the protein in those two compartments. This process requires energy supplied by adenosine triphosphate (ATP). As you learned on page 32 of the textbook, the mitochondria inside cells produce ATP.

Phagocytosis is a highly specialized form of transport also referred to as *cell eating.* In this process, the cell engulfs a particle by drawing it into an enfolding of the cell membrane, similar to the process of pinocytosis described on page 32 of the textbook. In phagocytosis, the cell engulfs a large particle (e.g., a white blood cell engulfs a bacterium). In *pinocytosis*, the cell engulfs particles that are dissolved in solution.

Specialization and Aging

So far we've been discussing fundamental concepts applicable to cells in general. But although your body's cells are similar in many ways, they're also different. The heart cells look and function differently from lung cells. Each organ and type of tissue in your body is composed of specialized cells and their products. It's as if your body is a complex society with different members of the society performing certain tasks. This process of specialization begins early in development while the embryo is still in the mother's womb. Once a cell becomes a heart cell, it can no longer become any other type of cell. Without the process of specialization, there would be nothing more than simple single-celled organisms on the earth. Figure 3-9 on page 41 illustrates how different two types of cells can be.

Read the "Effects of Aging on Cells" section on page 41 of the textbook. In an elderly person, cells can't divide as effectively as they did when the person was younger. This fact may explain why certain organs don't function very well as age increases. As our population ages, it's important to recognize disorders and conditions that afflict the elderly.

Read the "Medical Highlight" on genetic engineering and cloning on page 42. Genetic engineering has the potential to bring about vast changes in the way we diagnose and treat diseases. Cloning whole animals is a controversial issue, yet experiments continue. Mammals and other advanced species usually reproduce sexually, meaning that genetic material from the father and mother is combined. The offspring has a mixture of genes from both mother and father. Cloning is essentially an alternate form of reproduction in which the offspring derives genetic material from a single parent.

Disorders of Cell Structure

You've already learned that your body is composed of innumerable cells and the products they secrete. It should come as no surprise that disorders at the cellular level can result in disease and illness. This is especially evident when you consider tumors. Pages 43–44 and Figure 3-10 describe some disorders related to cell structure. There are many terms describing these disorders. Remember that the terms "tumor" and "neoplasm" both indicate the abnormal and uncontrolled growth of cells. However, this doesn't mean that all tumors or neoplasms are signs of deadly diseases. Tumors can be *benign* or *malignant.* Benign tumors exhibit abnormal and uncontrolled cell growth, but they don't result in death. Sometimes their size causes pain or compression against nearby structures. Examples of benign tumors include

- Benign breast tumor—can be completely removed with surgery, with no chemotherapy or radiotherapy required
- *Lipoma*—tumor of fat cells
- Nodule in the thyroid gland

On the other hand, malignant tumors (i.e., true cancers) can cause serious illness and even death. Cancerous cells don't obey the laws and restrictions that usually control cell growth. For example, some cancer cells that have been isolated for research purposes have continued to divide and multiply for decades in laboratories. Study Figure 3-10 to learn some differences between normal and cancer cells. Cancer cells essentially divide and multiply at the expense of normal, healthy cells. The cells may be initially concentrated in one place, forming a tumor. Some cancers have the tendency to send forth cells into distant sites of the body in a process called *metastasis*. A cancer will generally progress until it overwhelms the victim or is eradicated by medical treatment. Just as normal cells are specialized, most cancer cells can be traced back to a specific type of tissue. Usually a mutation causes cells to become abnormal and develop into cancer. It's important to identify the specific type of cancer to determine the best treatment plan. Cancer can be treated with surgery, chemotherapy, or radiotherapy. Some of the more common cancers include cancers of the lung, colon, breast, and prostate.

Now, review the material you've studied here. Once you feel you understand the material, complete *Self-Check 3*. Then check your answers with those provided in the study guide. When you're sure you completely understand the materials from Assignment 3, move on to Assignment 4.

Self-Check 3

Reinforce what you've just learned by answering Review Questions 1, 4, and 5 on page 45 of your textbook; Labeling Questions 1 and 9 on page 46, and Completion Questions 1 and 2 on page 47.

Check your answers with those on page 119.

ASSIGNMENT 4: TISSUES AND MEMBRANES

Read Assignment 4 in this study guide. Then read Chapter 4, pages 50–64, in your textbook, *Body Structures & Functions.* There are no corresponding sections in the CD-ROM for this assignment.

So far you've been learning about atoms, molecules, cells—components too small to be seen with the naked eye. In this assignment, you'll read about *tissues* and *membranes.* These components represent the next level of organization in the human body. You can see an example of tissue by looking at yourself. Your own skin is a tissue—*epithelial* tissue. A tissue is a body of cells organized to perform a certain function. Note that tissue may also contain nonliving substances produced by the cells. These substances make up the *extracellular matrix,* which is a complex network of proteins, fluid, and various molecules that support the cells.

Tissues

Study Table 4-1 on pages 52–56 for a more complete description of tissues. There are four different tissue types: epithelial, connective, muscle, and nerve. Read about each type and subtype of tissue in the textbook, then refer back to this study guide for additional information on selected topics. The outer layer of skin is the most obvious type of *epithelial tissue. Squamous epithelial cells* form the outer layer of skin, but they serve much more than a cosmetic role. Your skin protects against invasion from bacteria and other infectious organisms. Throughout life, you collect a thin film of bacteria on your skin. If these squamous epithelial cells didn't form a tough barrier, the bacteria would penetrate the skin and invade your body. Disorders in which this barrier is lost—such as in burns—can place an individual at great risk for infection. The lining of your digestive tract, including the stomach and intestines, is also a type of epithelium. Although this tissue appears to be on the inside of your body, it actually covers the external surface just as skin does. Consider your body as a very complex tube. Your skin covers the outer exterior surface of the tube. The lining of your digestive tract covers the inner exterior surface of the tube. Your organs are between the outer and inner exterior surfaces of the tube. When you eat a meal, the food doesn't actually enter the body until it crosses the inner exterior surface of the tube. If you eat something that isn't digested or absorbed, it passes out when you have a bowel movement. Thus, this substance technically never enters your body.

Columnar epithelial cells are so named because of their column-like shape. *Endocrine gland cells* secrete their products directly into (i.e., [endo-]) the bloodstream. *Exocrine gland cells* don't secrete into the bloodstream, but rather secrete into some other compartment of the body. They secrete outside of (i.e., [exo-]) the bloodstream. For example, certain cells in the pancreas secrete digestive enzymes into the intestines.

Connective tissue comes in many different forms. The main purpose of connective tissue is to provide physical support and protection for the body's other tissues and organs. *Cartilage* is the rubbery, smooth material that lines the surfaces of joints. *Arthritis,* or inflammation of the joints, can lead to severe damage of the cartilage. *Adipose tissue* is a form of connective tissue that can also provide energy in the form of lipid molecules. Other types of specialized connective tissue are the *blood* and *lymph.* You'll learn more about blood and lymph in *Anatomy and Physiology 2.*

Muscle tissue is involved in almost every bodily activity that you're aware of. The contraction of muscles helps you move your arms, walk around, and take breaths. Without the small muscles that control the movement of your eyeballs, you would have a difficult time reading this study guide. The muscles that perform these movements are *skeletal muscles,* named as such because they attach to some part of the skeleton. These muscles are under *voluntary control,* meaning that you initiate, continue, and stop these movements. It may not seem like you have to think about walking, but you do make the decision to start walking. Your muscles are so accustomed to walking that it seems automatic for you.

However, you can start and stop whenever you wish. And you can control the speed and force of the muscular contractions. Not all muscles are under voluntary control. Your intestines propel food along by way of *smooth muscle* cells inside the intestinal walls. These muscles are involuntary in that you can't control the timing or force of the contractions. The heart, the most vital muscular organ in the body, isn't under voluntary control. Your heart automatically adjusts the rate or force of contractions in response to many different stimuli. A heart attack is essentially the death of some part of the heart muscle. You'll read more about the heart in *Anatomy and Physiology 2.*

Nerve tissue is organized in the form of the brain, spinal cord, and nerves. This remarkable network of tissue coordinates the functioning of the entire body. The fundamental unit of nervous tissue is the *nerve cell* (or *neuron*). Neurons are specially designed to conduct signals from one end of the cell to another. These signals, racing along the network of nervous tissue, make it possible for you to feel pain, smell odors, see sights, hear sounds, and taste food. In your brain, these signals culminate in conscious thought and memory. Almost every part of the body is regulated in part by neurons. Even the blood vessel diameter is influenced by the action of tiny nerves that course along the vessels. Subsequent assignments in this course will discuss the nervous system in more detail.

Membranes

Read about membranes on pages 51–57. Figure 4-1 on page 51 depicts epithelial membranes. The two major classifications of membranes are *epithelial* and *connective.* Connective membranes will be discussed later in this study guide. The basic hierarchy of epithelial membranes is described next.

Epithelial Membranes

The two major classifications here are *mucous* and *serous.*

Mucous membranes. These membranes include those in the digestive tract (from the mouth to the anus); the respiratory passages (from the larynx to the tiny air sacs in the lungs); and the *genitourinary tract* (including the inner linings of the kidneys, ureters, bladder, urethra, and vagina).

Serous membranes. There are three different types of serous membranes. The first are pleural membranes (i.e., lining the pleural cavity). The *parietal pleural membrane* lines the inside of the rib cage, whereas the *visceral pleural membrane* lines the outside of the lungs. Pleural membranes produce a small amount of pleural fluid to lubricate the expansion and contraction of the lungs. Thus, the pleural membranes essentially create a pleural cavity that surrounds the lungs. Inflammation of the pleura is called *pleuritis.* The suffix [-itis] indicates inflammation of an area.

The *pericardial membranes,* which represent the second classification of serous membranes, encase the heart. These membranes are similar in principle and function to the pleural membranes. They produce a small amount of pericardial fluid to allow the heart to beat freely with minimal friction. Inflammation of the pericardial membranes is called *pericarditis.*

The third classification of serous membranes, the *peritoneal membranes,* line the peritoneal (abdominal) cavity. The *parietal peritoneal membranes* line the inner surface of the peritoneal cavity. The *visceral peritoneal membranes* line the outer surfaces of the stomach and intestines. The space between is the peritoneal cavity. Inflammation of this cavity is called *peritonitis.*

Organs and Systems

At the simplest level, the human body is composed of atoms arranged in a complex hierarchy that yields our living, breathing selves. In this course, we've approached the human body by starting at the simplest level and moving upward through levels of complexity. Figure 4-2 on page 58 presents an excellent, yet simplified, snapshot of how our bodies are organized. The four major atoms contained in the body are *carbon, hydrogen, nitrogen,* and *oxygen.* These combine to make the organic compounds and other molecules that we learned about in Assignment 2. The organic compounds are assembled into the various organelles that reside inside cells. Organelles are like mini-organs for the cell. Of course, the human body has countless numbers of cells. These cells are arranged in the four tissue types previously discussed in this assignment. Next, each organ is an assemblage of several different tissue types. For example, the stomach's inner lining is an epithelial layer. Several sheets of smooth muscle tissue make up the middle layer. This muscle allows the stomach to churn food particles during digestion and contract during vomiting. The outer layer of the stomach is a type of epithelium. Arteries, veins, and nerves also course through the walls of the stomach. The arteries supply blood and oxygen, whereas the veins drain away the blood and waste products. The nerves control the muscular contractions of the stomach. Various forms of connective tissue lend support to the stomach. So you can see the stomach contains all four types of tissue.

As capable as each organ may be, the organs don't function in isolation. The stomach would be of little use without the esophagus or intestines. Thus, the organs work together in organ systems. Study the 10 organ systems in Table 4-2 on page 59 of your textbook. Each organ within an organ system is vital for performing the system function. For example, in the nervous system, the spinal cord conducts signals from the brain to the nerves. The nerves either stimulate other organs and tissues or they receive sensory feedback from them. Any break along this chain results in a malfunction of the nervous system. In turn, all 10 organ systems are essential for the health of the whole organism. Yet each organ system is so complex that medical specialties have evolved to focus on each system and its associated problems. For example, a *pulmonologist* specializes in respiratory disorders, whereas an *endocrinologist* concentrates on endocrine diseases.

Tissue Repair

You may have heard that some lizards can regenerate a whole tail after it's broken off. Although humans can't duplicate that feat, our bodies are able to heal most wounds. Read about tissue repair in textbook pages 57–60. Wound healing occurs by repair of injured tissue. Note that the formation of a scab in some wounds is a normal event in the process of wound healing. As the edges of epithelium grow back together, the scab eventually disappears. A scar, however, never completely disappears. It may fade over a period of years, but the scar will always be there. Scar tissue is essentially the body's method of sealing the edges of a wound. Some scars appear as a thin line. Others are quite broad and extensive, as occurs after the healing of a large, deep wound. The scar itself is a dense mat of fibrous material that appears only after normal tissue is damaged (i.e., a normal response to injury). Scars can be found anywhere in the body (i.e., not just on the skin). As mentioned before, a heart attack is the death of part of the heart muscle. This dead muscle is eventually replaced by scar tissue. Cells and components of the immune system are responsible for the overall process of wound healing. You'll read about other aspects of the immune system in relation to healing in *Anatomy and Physiology 2.*

The speed and effectiveness of wound healing depends on many factors. Simple wounds heal faster and better than complex, deep, or dirty wounds. Healthy individuals heal wounds better than those individuals who have chronic diseases. The following factors can affect wound healing.

- Poor circulation to the wound area means that the wound isn't receiving adequate oxygen for the process of healing.
- Infection in the wound will prevent the cells of the immune system from functioning normally.
- Several drugs can interfere with the immune system.
- Lack of sufficient protein in the diet will deny the body the necessary building blocks for wound repair.
- Deficiency of certain vitamins can impair wound healing. (See Table 4-3 on page 60 of the textbook.)

Now, review the material you’ve studied here. Once you feel you understand the material, complete *Self-Check 4*. Then check your answers with those provided in the study guide. When you’re sure you completely understand the materials from Assignment 4 move on to Assignment 5.

Self-Check 4

Reinforce what you’ve just learned by answering Review Questions 1, 3, 6, 9, and 10 on pages 61–62 of your textbook.

Check your answers with those on page 120.

ASSIGNMENT 5: THE INTEGUMENTARY SYSTEM

Read Assignment 5 in this study guide. Then read Chapter 5, pages 65–82, in your textbook, *Body Structures & Functions.* In your CD-ROM, *Anatomy & Physiology,* read the segment entitled "Skin, Hair, and Nails" in the Anatomy and Physiology section. This interactive segment will supplement the information in your textbook. Also on the CD-ROM, view the segment entitled "The Outer Layer" in the Fascinating Educating section. You should view the CD-ROM in conjunction with the textbook and also later as a review and self-assessment. When referring you to a specific part of the CD-ROM, this study guide will use this format: Major Heading/Minor Heading/Topic. For example, the section on itching entitled "Itching to Scratch" will be referred to as Fascinating Educating/The Outer Layer/Itching to Scratch.

Now you're ready to tackle the actual organ systems. Each assignment in this next session focuses on a particular organ system. The first system is the *integumentary system,* comprised of the skin, hair, and nails. Although the skin may appear to be an inactive sheet of tissue, it's a dynamic organ with blood vessels and nerves just like any other organ. The skin serves several different functions and interacts with several organ systems. Let's begin this assignment with a mental exercise. Before reading the textbook pages, take a few minutes to think about your own skin. What's its purpose? What does it do? Next to each term listed in Exercise 1, jot down your thoughts about how skin is related to that term.

Exercise 1

- Protection ____
- Body temperature ______________________________________
- Vitamin D ____
- Sensation ____
- Storage ____
- Absorption ____

Skin Function and Structure

Read about the main functions of skin described on page 66 of your textbook. Take a moment to go back to Table 4-2 on page 59 of your textbook to review the information on the integumentary system. How did your own thoughts regarding this system fare against the information in the textbook? The skin is surprisingly versatile and complex. Study Figure 5-1 and notice that all these nerve endings are contained in only one square inch of surface area. How is it possible for one square centimeter to contain four yards of nerves? These nerves are tiny—even microscopic. They represent the very smallest branches of the peripheral nerves. This intricate system of nerves allows you to sense the very subtle changes in the immediate environment. Your skin senses pressure, temperature, and pain with different types of nerve fibers. But you don't perceive these various senses as separate sensations. Your brain integrates all signals from the skin's nerves to produce a single sensation. For example, if you accidentally touch a hot stove, you'll feel hot, painful pressure. It's interesting to note that the itch sensation may be carried by distinct nerve fibers. See Fascinating Educating/The Outer Layer/Itching to Scratch on the CD-ROM for more information on itching.

Notice in Figure 5-1 how a single centimeter of skin also contains a yard of blood vessels. These are tiny arteries and veins that not only serve the skin itself, but also allow the skin to help regulate body temperature. Think of the last time you exercised. Whenever you exercise, your heart rate increases to deliver more oxygen to your working muscles. The metabolism of your muscles generates heat. To maintain a stable body temperature (i.e., one aspect of homeostasis), your body must get rid of this extra heat. This mainly occurs through sweating. Evaporation of sweat from your skin carries away heat. The tiny blood vessels in your skin also dilate to lose heat, making your skin warm and flushed. In the opposite situation, when you need to conserve heat, the vessels in your skin become more constricted. This shunts blood flow, along with heat, away from skin to vital internal organs.

Now read about the two layers of skin, the *epidermis* and *dermis.* Pay close attention to Figure 5-2 on page 67 in the textbook as well as the figure in Anatomy and Physiology/ Skin, Hair and Nails/Skin in the CD-ROM. One of the many amazing aspects of skin is the extensive amount of *cell turnover* (i.e., cells continually die and are replaced by new cells). High rates of cell turnover tend to occur in epithelial layers, such as skin or the mucosal lining of the digestive tract. In the skin, the most superficial cells are the *keratinocytes,* thus called because they contain the protein keratin. They're actually dead cells that have been pushed up to the surface of the skin by the newly formed cells in the deeper layers. Your skin is constantly shedding these dead cells into the environment. In fact, much of the dust in your home is made of shed keratinocytes. As the dead cells slough off, new keratinocytes emerge from the *stratum germinativum* (i.e., the deepest epidermal layer consisting mostly of keratinocytes) and the *stratum spinosum* (i.e., epidermal layer containing melanocytes, keratinocytes, and Langerhans cells).

The underlying dermal layer is much thicker than the epithelial layer. It contains nerves, blood vessels, and skin appendages. It also contains connective tissue and muscle tissue. This demonstrates that the skin is a true organ with many different types of cells and tissues. The dermis is also the layer of skin that takes on the color of a tattoo, which you can read about in Fascinating Educating/The Outer Layer/Tattoos: Marked for Life.

Skin Appendages

We tend to think of hair simply as long structures growing out of our skin. Yet each piece of hair on your body is a complex entity with a full support system. The text on page 69 describes some features of hair. Correlate this information with the figure in Anatomy and Physiology/Skin, Hair and Nails/Hair/Study Hall in the CD-ROM. Read about baldness in Fascinating Educating/The Outer Layer/The Bald and Beautiful in the CD-ROM.

We may take our fingernails and toenails for granted. But the nails are dynamic structures with definite functions. For example, your fingernails protect the soft pulp of your fingertips from trauma. They also lend physical support to the fingertips to allow you to pick up small objects. Study the figure in Anatomy and Physiology/Skin, Hair and Nails/Nails/Study Hall in the CD-ROM.

In addition to hair and nails, your skin also has special glands. Refer back to Figure 5-2 on page 67 in the textbook to study the structure of sweat and sebaceous glands. The sweat glands excrete a mixture of water and waste products. As mentioned earlier in this assignment, the secretion of water aids in getting rid of excess heat. But perspiration also contains a small amount of waste product. This is why the skin is considered a part of the excretory system as well as the integumentary system (as was shown in Table 4-2 on page 59 in the textbook).

Protection from Infection

As mentioned previously in Assignment 4, the skin plays a major role in preventing infectious organisms from entering your body. Any substantial break in the skin barrier—such as a burn, laceration, or abrasion—can represent a portal for infection. Individuals who have diabetes are especially prone to developing infections, even after sustaining small wounds in their feet. It's also important to note that infections can be spread from person to person through skin contact. When health care workers first started washing their hands on a regular basis, the mortality of hospitalized patients decreased dramatically. This is because handwashing reduces the bacterial load spread from person to person. In fact, the advent of routine handwashing is one of history's most significant advances in health care. It's thought that the most contaminated part of the hand is underneath the fingernail. Read more about fingernails in the CD-ROM, Fascinating Educating/The Outer Layer/Long Fingernails and the Link to Infection.

Effects of Aging and Common Disorders of the Skin and Appendages

Aging is a normal process that affects every organ system in the body. Skin changes are the most readily obvious. Read about these changes on page 71 in the textbook. Wrinkling of skin is one of the major concerns of people as they age. Entire industries have thrived on our willingness to buy products or undergo procedures to eliminate wrinkles. Read about one of these procedures in the CD-ROM, Fascinating Educating/The Outer Layer/Are You Ready for a Skin Peel?

Pages 71–77 of the textbook describe common disorders of the skin. Correlate the descriptions with the photos in Figures 5-4, 5-5, and 5-6. In the following text you'll find an outline of the various categories of common skin disorders. (Note that the order of categories here isn't exactly the same as that presented in your textbook, but it should make the concepts easier to grasp.)

Bacterial. Infections caused by bacteria (e.g., *impetigo* [Figure 5-4, D], *boils, carbuncles*) are treated with antibiotics and possibly drainage of the infected fluid.

Fungal. Infections caused by fungi (e.g., *athlete's foot* [Figure 5-4, A], *ringworm*) are treated with specific antifungal agents.

Viral. Infections caused by viruses (e.g., *herpes simplex* [Figure 5-4, G], genital herpes, shingles [*herpes zoster,* Figure 5-4, H]) can be treated with antiviral medications. However, the lesions tend to recur during the patient's lifetime.

Inflammatory Skin Disorders

Dermatitis. Dermatitis is a general term referring to any inflammation of the skin. Thus, a bacterial infection such as impetigo can be correctly described as dermatitis. Some forms of dermatitis aren't infectious, such as *contact dermatitis* (Figure 5-4, B).

Eczema. This inflammatory disorder can be caused by a variety of factors. Sometimes eczema is associated with other inflammatory disorders such as asthma. Like many inflammatory skin conditions, this condition is primarily treated with *topical* (i.e., applied directly to the skin as a lotion, cream, or ointment) *corticosteroids,* which have anti-inflammatory properties.

Psoriasis. Psoriasis (Figure 5-4, E) can also present in the form of a generalized disorder, sometimes affecting the joints. Although there's no definitive treatment for this disorder, corticosteroids can reduce the severity of the inflammation.

Urticaria or hives. This inflammatory disorder (Figure 5-4, F) is usually caused by ingestion of an allergen (either food or a drug). Read about hives in the CD-ROM, Fascinating Educating/The Outer Layer/Hives: An Allergic Reaction.

Cancerous Skin Disorders

All skin cancers (i.e., *basal cell* and *squamous cell carcinoma* and *malignant melanoma* [Figure 5-5]) arise from cells in the epidermis, but these cancers can spread to deeper tissues and even to distant sites such as the lungs. The main risk factor for skin cancer is unprotected exposure to the sun. Read about skin cancer in the CD-ROM, Fascinating Educating/The Outer Layer/Skin Cancer and the Sun.

Burns

Burns can range from mild sunburns that clear up in a few days to destructive, life-threatening third degree burns. Read about burns on page 74 of the textbook and study Figure 5-6 on page 75. The factors that determine how a person will react to a burn are the patient's underlying medical conditions and the surface area, depth, and location of the burn. Patients with chronic medical conditions such as diabetes, kidney failure, and heart failure are generally less able to tolerate the physiological changes that occur with burns. Although *first degree burns* heal without specific treatment, *second degree burns* require careful wound care. *Third degree burns* usually require skin grafting, a type of surgery in which the burned skin is removed and replaced with skin from another location. However, the larger the surface area affected by the burn, the greater the risk of complications or death. Thus a second degree burn covering 50% of the body's surface area is generally more serious than a third degree burn covering 5%. Location is also important, because a small burn of the hand would have a greater overall impact than a larger burn on the back.

Other Skin Lesions

An *ulcer* is a depression of the epidermis. It can progress to erosion of the skin layers. *Pressure ulcers* (or *decubitus ulcers*) are specifically caused by direct pressure due to prolonged immobility. They occur at points that bear the most pressure when somebody is sitting or lying down for long periods, such as the heels, tailbone (coccyx), elbows, and the back of the head. Patients who have suffered a stroke or coma or are otherwise immobile are at the greatest risk for developing pressure ulcers. We normally shift our weight at frequent intervals, even doing it subconsciously during sleep. But these patients can't shift their weight, so they can develop pressure ulcers rapidly. They require regular repositioning by family members or health care workers to prevent the ulcers. Once an ulcer has formed, it will never heal unless aggressive measures are taken to relieve the pressure. The ulcers may also require surgery to remove dead or infected tissue.

Study the other categories of skin lesions in Figure 5-7 on page 76 and Table 5-1 on page 77 of your textbook. Note that these general terms describe skin lesions but don't specify any particular disease. For example, *pustules* are skin lesions that occur in a variety of skin conditions, such as *acne,* impetigo, *furuncles,* and *carbuncles.*

The CD-ROM contains information on other conditions of the integumentary system. Make sure that you view all the vignettes under Fascinating Educating/The Outer Layer in the CD-ROM. You should have already viewed some of them. For the remaining vignettes that appear in Exercise 2, jot down one interesting fact that you learned.

Exercise 2

- Head Lice: At Home in Your Hair

  ____

- Artificial Fingernails and the Price of Beauty

  ____

- Why Do I Have Pruny Fingers?

  ____

- She's Not Blushing . . . It's Rosacea

  ____

Now, review the material you've studied here. Once you feel you understand the material, complete *Self-Check 5.* Then check your answers with those provided in the study guide. When you're sure you completely understand the materials from Assignment 5, move on to Assignment 6.

Self-Check 5

Reinforce the material you've just learned by playing the Match Games in Anatomy and Physiology/Skin, Hair and Nails in the CD-ROM for the individual sections on skin, hair, and nails. Then answer Review Questions 2, 3, and 5 and Completion Questions 4 and 6 on page 79 of your textbook.

Check your answers with those on page 120.