

SECTION 1 Anatomy Relevant to Kinesiology

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CHAPTER 1 Fundamentals of Anatomy

CHAPTER OBJECTIVES

After completing this chapter, the student will be able to:

- 1. describe how the body is organized;
- 2. define and use anatomical terminology;
- 3. recall the body regions;
- 4. name the body planes and the axes of rotation; and
- 5. match the body planes and axes of rotation.

The word "anatomical" refers to the study of the structures of an organism. From the word kinesiology, the root word "kines" means movement and the suffix "-ology" is "the study of." Thus, **kinesiology** is the study of body movement. Therefore, **anatomical kinesiology** is the study of the structures most relevant to body movement. Additionally, **physiology**, the study of the functions of the structures of an organism, must also be learned. This chapter will start with a general overview of the anatomy and physiology of the entire body and end with the terms most relevant to anatomical kinesiology.

Organization of the Body

All organisms, including the human body, have a hierarchy of organization. This **hierarchy** refers to an increasing complexity of structural and functional units. From the smallest to the largest, the hierarchy follows this pattern:

- Cells
- Tissues

- Organs
- Organ Systems
- Organism

Cells

The cell is the smallest functional unit of life. There are smaller parts within a cell, but none are considered a "unit of life." The cells of an organism are ultimately responsible for all the functions of an organism. However, a single type of cell only performs one function. Therefore, there are a number of different types of cells to perform various functions of an organism. For instance, a skin cell and a muscle cell play completely different roles.

Some cells are less complex than what is shown in **FIGURE 1.1**, but there is much commonality among most types of cells. All cells have three main components: the *cell membrane*, the *cytoplasm*, and the *nucleus*. The **cell membrane** serves as a semipermeable barrier between its internal environment and what lies outside of it. This barrier allows for the free flow of some substances and a controlled sharing of other substances.





FIGURE 1.2 The Types of Tissue.

FIGURE 1.1 A Typical Cell.

The **cytoplasm** is everything within the plasma membrane except the nucleus. The cytoplasm includes the organelles, the cytoskeleton, and the cytosol. The **organelles** are a group of structures that collectively carry out the function of the cell. The **nucleus** is also grouped with the organelles, but it is not considered part of the cytoplasm. The nucleus houses the genetic code (DNA) which controls the activities of the cell. The **cytoskeleton** is a network of protein filaments that provide structure for the cell and organize its contents. The **cytosol** is a gel-like substance that fills all the gaps within the cell, but not inside the nucleus.

Tissues

A **tissue** is a group of similar types of cells and the fluid in between them called intracellular (between cells) fluid or tissue fluid. There are four main types of tissues. They are epithelial, connective, muscular, and nervous (**FIGURE 1.2**). **Epithelial tissue** covers internal and external surfaces. The skin is a prime example of epithelial tissue as well as the membranes that line internal body cavities and organs. **Connective tissue** does exactly that; it connects things such as tendons connecting muscles to bones. Connective tissue has the most diverse varieties of any other tissue type. Some of these are bones, ligaments, cartilage, tendons, and adipose (fat) tissue.

Nervous tissue and muscular tissue are sometimes called the *excitable tissues* because they both are built to respond to stimuli. **Nervous tissue** is highly specialized and reacts to a much broader range of stimuli than muscular tissue. Basically, nervous tissue and its cells react to various stimuli to provide a communication highway between the brain and the body. When **muscular tissue** is excited, it does something that no other tissue is capable of: it contracts. Muscular contraction uses energy to perform mechanical work. In other words, muscular contraction generates a force which is used to move things.

Tissues can also be described as being in layers. The **general layers of tissue**, from superficial to deep, are 1) the **skin**, 2) the **hypodermis**, 3) the **muscular** layer, and finally 4) the **skeletal** layer (**FIGURE 1.3**). All of these general layers contain more than one type of tissue but are named so because of the tissue that is the most abundant in that layer.

Organs

Organs are groups of different tissues that perform a more complex function than any single tissue or cell. An example is the heart organ. The purpose of the heart is to apply pressure to the blood so it will flow through the blood vessels (**FIGURE 1.4**). Some of the tissues are epithelial and create an outer shell that holds the heart together. Other inner tissues provide the structure of the chambers of the heart. Still others, which are muscular tissue, squeeze the blood in the chambers. All these tissues work together to apply pressure to the blood so it will flow through the blood vessels and supply all the cells.

Organ Systems

Organ systems are groups of organs working together to perform an even more complex role than a single organ. For example, the cardiovascular system has three main sets of organs which are the blood, the heart, and the blood vessels (**FIGURE 1.5**).



FIGURE 1.3 The Skin and Hypodermis (left) and the Muscle and Bone Layers (right).



FIGURE 1.5 The Cardiovascular System.

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The overall, basic purpose of the cardiovascular system is to supply the cells with needed items and transport waste from the cells for excretion. The blood is the medium through which all these things are transported. However, blood will not flow throughout the body without the heart applying pressure to it. Furthermore, the blood vessels are needed to contain and direct the blood to the cells. So, the organs of the cardiovascular system work together to perform a larger function. Finally, the collective roles of the cells, the tissues, the organs, and the organ systems result in an organism (person) having a vast and amazing array of abilities.

PAUSE TO CHECK FOR UNDERSTANDING

- 1. Is the word "anatomy" or "physiology" defined as the study of structures?
- Rearrange the following terms so they are in the correct order from the most complex to the most basic:
 - tissue organism cell organ organ system
- 3. What is the smallest, basic unit of life?
- **4.** What are the four types of tissues and their basic function?

Anatomical Terminology

Knowledge of the terms that describe anatomy is imperative. It is necessary to label or name the body parts so there is commonality for discussion and explanation.

Body Positions

General body positions include standing, sitting, and lying down. These body positions are self-explanatory. However, these general body positions do not specifically address the position of body parts in relation to each other. *Anatomical position* solves this dilemma.

Anatomical position is the established reference point for body position (**FIGURE 1.6**). For instance, having a reference point is necessary to establish what is to be called the front, the back, the top, the bottom, the



FIGURE 1.6 Anatomical Position (left) and Fundamental Position (right).

right, and the left sides. The gold standard, accepted anatomical position is standing erect, facing forward, arms straight at each side with forearms rotated so that the palms face forward, and legs straight with the feet together. Another standing position is **fundamental position**, which is the same as anatomical except the forearms are rotated so that the palms are facing the sides of the body (**FIGURE 1.6**). Fundamental position is the typical, natural stance of a person and this position is used when measuring joint motions.

Supine and *prone* are two more general body position terms used to describe lying down. (**FIGURE 1.7**). **Supine** refers to the body lying flat on the back. A **prone** body position is the opposite with the body lying flat on the front side.

Directional Terms

There are several terms that describe the location of body parts (**FIGURE 1.8**). **TABLE 1.1** summarizes the definition of these terms. Some of the directional terms



FIGURE 1.7 Supine (left) and Prone (right) Body Positions.



FIGURE 1.8 Directional Terms.

TABLE 1.1 Definitions of Directional Terms				
Term	Definition			
Anterior	towards front			
Posterior	towards back			
Ventral	towards belly or front			
Dorsal	towards back or spine			
Cephalic	towards head			
Caudal	towards tail or lower end			
Superior	above			
Inferior	below			
Proximal	nearer the midline (beginning of structure)			
Distal	farther from midline (end of structure)			
Medial	nearer the midline (side of structure)			
Lateral	farther from midline (side of structure)			
Ipsilateral	same side			

Contralateral	opposite side
Unilateral	one side
Bilateral	both or two sides
Superficial	closer to body surface
Deep	farther from body surface

were derived from the study of animals. Many years ago, scientists utilized animals more so than humans because of access and the general similarities between the species.

Anterior means "towards the front" and **posterior** is the opposite meaning "towards the back." Similar to these terms are ventral and dorsal and are examples of terms originating from the study of animals. **Ventral** literally means "towards the belly."

However, it is still important to understand because it sometimes refers to the front because the belly of a human is on the front side. **Dorsal** means "towards the spine." Like ventral, dorsal sometimes refers to the back in humans because that is where our spine is. The spine in four-legged animals is on the top side of the body and is used in this manner in the human foot. The top side of the foot is the dorsal side.

Cephalic and caudal are two more terms that originated from the study of animal anatomy. **Cephalic** means "towards the head." **Caudal** means "towards the tail" and is the trailing or end part of an animal. In human anatomy, caudal means "towards the lower end" which is towards the feet. Similar to these are superior and inferior. **Superior** means "above" as in towards the head. **Inferior** means "below" and also refers to towards the feet. Superior and inferior are used mostly to indicate direction or relative position in the axial region (head, neck, chest, back, abdomen, and pelvis). Two different terms are used in a similar fashion mostly for the appendages (arms and legs).

Proximal means "nearer to the midline" and refers to being towards the beginning of a structure or the end that is closer to the midline. **Distal** means "farther from the midline" and refers to the end of a structure; the end farther away from the midline. Medial ("nearer the midline") and lateral ("farther from the midline") are two more terms that share the same root definitions as proximal and distal. However, these terms are used to indicate sides rather than ends of a structure. For instance, the medial forearm bone refers to the bone that is closest to the midline while the lateral forearm bone is on the side farthest from the midline.

Four other terms are related to sides. They are *ipsilateral*, *contralateral*, *unilateral*, and *bilateral*. **Ipsilateral** literally means "same side" and **contralateral** is "opposite side." For example, the right arm is ipsilateral to the right leg while the left leg is contralateral to both of them. These terms could also be used to indicate the location of structures on the same body part. **Unilateral** means "one side" while **bilateral** refers to both sides.

Most of the terms to this point are relevant to height and width, but what about depth? The terms superficial and deep indicate depth in both the axial and appendicular regions of the body. **Superficial** means "closer to surface of a body" while **deep** means "farther from the surface of a body." For instance, the skin is the most superficial body part while all other organs are deep to the skin.

PAUSE TO CHECK FOR UNDERSTANDING

- 1. Describe the differences between anatomical and fundamental position.
- 2. Is "prone" or "supine" lying on the back or face up?
- **3.** Draw a three-dimensional box and label each side including the top and bottom with the appropriate directional terms.
- 4. To represent legs, add two more three-dimensional long boxes to the bottom of your first box. Using the rest of the directional terms, label them.

Body Regions

The body is divided into a number of regions and sub-regions. The two main regions are the axial and the appendicular regions (**FIGURE 1.9**). The **axial region**



FIGURE 1.9 The Axial and Appendicular Regions of the Body.

is composed of the head, neck, and trunk (chest, back, and pelvis). The **appendicular region** includes the four appendages (or extremities): the two upper extremities (arms) and the two lower extremities (legs).

The sub-regions of the axial region are indicated in **FIGURE 1.10**. The sub-regions of the upper extremities and lower extremities are indicated in **FIGURE 1.11** and **FIGURE 1.12**, respectively.

Body Planes

Observing an organism by its surface anatomy tells us much, but limits our understanding of the inner parts. Imaginary planes are used to "slice" a body into different parts to observe these inner parts and to view them from different sides. The imaginary planes are the *sagittal, coronal* (frontal), and *transverse* planes (**FIGURE 1.13**).







The **sagittal plane** divides an organism into left and right portions and gives a side view of a body part. A sagittal plane used to "slice" through the very center of the body is called the **midsagittal** plane. The midsagittal plane is also called the **median** or **midline**. The midline divides the body into equal left and right halves. The **coronal plane** (also called **frontal plane**) divides an organism into anterior and posterior sections. The **transverse plane** "cuts" an organism into superior and inferior parts. All of these planes can be used to "slice" the body in any number of areas in order to realize internal structures from a different point of view (**FIGURE 1.14**).





SUB-REGION	PERTAINING TO THE:	SUB-REGION	PERTAINING TO THE:
Coxal	hip	Calcaneal	heel
Femoral	thigh from hip to knee	Pedal	foot
Patellar	anterior side of knee (kneecap)	Dorsal	superior side of foot
Popliteal	posterior side of knee	Plantar	inferior side of foot
Crural	lower leg from knee to ankle	Digits	toes
Tarsal	ankle		



Frontal (coronal) Plane



Midsagittal Plane

FIGURE 1.13 The Body Planes.



Sagittal Plane (not on midline)



Transverse Plane



FIGURE 1.14 Three Views of the Shoulder.

Axes of Rotation

Each plane has an axis associated with it (**FIGURE 1.15**). Each of these axes is an imaginary line or rod that the different body regions rotate about. For example, when the knee is extended, it is rotating around the imaginary center line of the knee. When it rotates in the opposite direction, it is called knee flexion.

The **sagittal axis** passes from anterior to posterior through the frontal plane. The **frontal axis** passes from side to side of the body through the sagittal plane. The **longitudinal axis**, also called **vertical axis**, passes from superior to inferior through the transverse plane.

DAUSE TO CHECK FOR UNDERSTANDING

- Draw an anterior and posterior blank body similar to Figure 1.11. Then, label all the body regions. Maybe even add lines to delineate the regions.
- 2. What are the body planes and how do they divide the body?
- **3.** List the axes of rotation and tell which axis goes with each body plane.



FIGURE 1.15 Axes of Rotation within Planes.