CLINICAL APPLICATIONS OF HUMAN ANATOMY AND PHYSIOLOGY FOR HEALTHCARE PROFESSIONALS

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Clinical Applications of Human Anatomy and Physiology for Healthcare Professionals

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For my Mom and Dad – thank you for putting up with me through all these years

And, Bana Boo – my hero ☺

“Only a life lived in the service to others is worth living.”

—Albert Einstein

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FOREWORD

CLINICAL APPLICATIONS OF HUMAN ANATOMY & PHYSIOLOGY FOR HEALTHCARE PROFESSIONALS is an exceptional undertaking to educate student nurses on the basics of human anatomy and physiology. It is comprehensive yet straightforward with helpful illustrations to support learning content.

True to his style as a physician and author, Dr. Jassin Jouria has written a text for students on the topic of *Clinical Applications of Human Anatomy & Physiology for Healthcare Professionals* with extensive peer review by advanced nursing colleagues from varied practice backgrounds. This is to ensure nursing readers will gain from a wide perspective of expert clinicians who reviewed the text material for quality of presentation as well as relevance to nursing learning.

What do experienced nurses say about Dr. Jouria's text book?

The text chapters are easy to read and to understand. Aspects of human anatomy and physiology can be difficult to understand due to the many systems and body functions. The author takes the reader step by step through the varied body systems with easy to grasp explanations. The many illustrations and diagrams help to see what is being described in the text. The chapters are excellent.

Often nurses begin their careers with not a whole lot of experience in every body system. The text made an impressive effort to take readers through basic concepts of body system anatomy and physiology. The sections are well organized, and just the right amount of basic learning content for each body system.

New nursing students often feel overwhelmed when studying the complex parts of each body system, because there is just so much to remember. The text is concise and breaks down subtopics within each chapter to make learning very doable and interesting.

The case studies provided are poignant and often include contemporary health concerns.

All the information a student needs to know about varied body systems is discussed. The information presented is good and thorough and the level appropriate for nursing students.

Over the past years, it has been my great pleasure to work with Dr. Jouria to develop online learning content for nurses working in all areas of healthcare. Dr. Jouria's approach and thoughtful style to address healthcare topics and contemporary issues, and his keen interest in interdisciplinary health team roles, interprofessional collaboration, and support of the nursing profession have been greatly admired and appreciated.

S.F. DePasquale, MSN, FPMHNP-BC
Helena, Montana

PREFACE

ANATOMY AND PHYSIOLOGY has always been a very difficult subject to study, not to mention – to *master*. This textbook started out with the thought that any difficult subject should be broken down into separate components. Inherently, it is easy to break down anatomy and physiology into separate components as the human body is a compilation of separate organ systems functioning as a whole. While any good anatomy and physiology textbook is presented by organ system, this text is distinguished from other textbooks as it is streamlined to present the importance of the clinical significance of the organ system being studied. This author believes something is learned best by a group, when the group understands, and believes, in *why* they are learning the respective material.

ACKNOWLEDGEMENTS

I WOULD LIKE to express my gratitude to the following people who polished this book by providing their support, read, wrote, offered comments, allowed me to quote their remarks and assisted in the editing, proofreading and design.

Susan DePasquale, MA, MSN, FPMHNP-BC
Dana Bartlett, RN, BSN, MSN, MS, CSPI
Cindy Bauman, MSN, PMHNP-BC

CHAPTER

1

OVERVIEW OF HUMAN ANATOMY AND PHYSIOLOGY

Learning Objectives

At the completion of this chapter the student will be able to:

1. Define anatomy and physiology, and list the structural levels of organization in the human body.
2. Differentiate and understand the characteristics of living organisms.
3. Describe the role of homeostasis in the human body, and provide specific examples.
4. Identify the major organ systems of the body and describe their purpose.
5. Use proper anatomical terminology to describe the body and relative positions.
6. Discern and appreciate the types of movement of the body and their proper names.

Case Study Introduction

It's a cold, rainy Monday night and you just have one of those bad feelings. You are a Paramedic, and this feeling comes all too often. Suddenly, you and your partner are called to the scene of an automobile accident that has just occurred on the major highway leading into town.

As you arrive on scene, you find the driver unconscious and still in the car. On primary assessment, you notice that she is still breathing, though with difficulty, on her own. You see blood around her nose and mouth, and you hear a gurgling sound as she breathes. You also notice that she is wearing her seatbelt, but the vehicle air bags did not deploy.

Another person who witnessed the accident tells you that she saw the driver try to steer away from a truck that had lost control in the rain. However, the driver of the car, in the midst of maneuvering, also lost control of her vehicle and ended up veering off the highway, spinning out of control, and hitting the guardrail directly head-on before coming to a stop.

As your partner sets up the medical equipment, you take a secondary assessment. The victim's breathing is shallow and rapid, with multiple lacerations on her face. She has a thready radial pulse of 150 beats per minute, and her blood pressure in 90/50. Respirations are at 28 breaths a minute, diminished on the right side.

Case Study Introduction (continued...)

Your partner hands you a cervical collar and you place it on the victim, stabilizing her cervical spine. You crew arrives and together the team pulls the victim out of the vehicle and places her on a backboard, transporting her to the ambulance. Inside the ambulance, you begin a more detailed survey, monitoring her vitals and looking for more injuries. You notice a large contusion on her sternum and several lacerations superior to the antecubital fossa, and on the medial aspect of her right arm. She also has a deformity on the lateral aspect of the left thigh. While you start all life-saving protocols, including IV fluids and an ECG, your partner calls the nearest hospital with the report you have given him.

INTRODUCTION

When studying the human body as a whole, a basic and step-by-step progression is the most logical approach. The human body is a complex and dynamic system composed of many different structures and functions. Therefore, a necessary and thorough understanding of the human body's anatomy and physiology is essential.

It is wise to always begin the study of any subject by first defining that subject. What is anatomy and physiology? Anatomy, by definition, is simply the study of a living organism's *structure* or its form, while physiology is the study of its *function*. More simply, anatomy is the study of what an organism looks like, and physiology is the study of how that living organism operates. Remember this: throughout the course of Anatomy and Physiology, you are simply learning ***form*** and ***function***.

Anatomy is further divided into gross anatomy and microscopic anatomy. Gross anatomy is studied through the dissection of anatomical structures visible to the naked eye. Microscopic anatomy, true to its namesake, is the study of very small anatomical structures that require the assistance of a microscope to be adequately seen. Moreover, it becomes sensible to classify the human body from its most simple to its most complex level of structural organization.

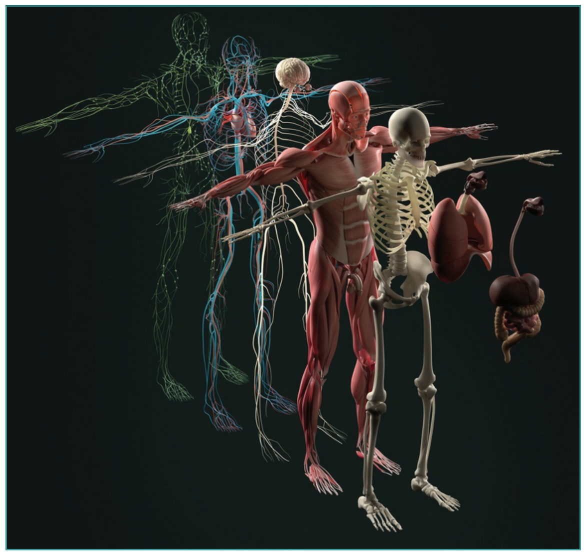

Figure 1-1 Organ systems.

Here we have one of the most basic, yet, extremely important aspects to the study of anatomy and physiology, (and hence a favorite test question for instructors and examiners worldwide); the order of the levels of structural organization of the human body, from the simplest to the most complex as follows:

Atom → Molecule → Cell → Tissue → Organ → Organ system → Organism

The following is an overly simplified, yet accurate example of the above: Atoms of hydrogen and oxygen form and function together to produce a molecule of hydroxide. Molecules (for example, hydroxide and phosphate) form and function together to produce the phospholipid bilayer of a cell.

A group of cells known as stratified squamous cells form and function together to produce a tissue called ***epithelium***.

The epithelial tissue forms and functions together to produce an organ called skin. The skin, hair, and nails form and function together to produce an organ system called the ***integumentary system***. The integumentary system forms and functions together with ten other organ systems to produce an organism – the human being.

Next, to fully understand the human as an organism, we must first look at the big picture, an overview if you will, of the body's form and function. One of the most fundamental concepts to keep in mind during your investigation of the human body it to remember that the body is a dynamic, living organism – that is the human body's structure and functioning must be maintained at all times via self-sustaining processes.

CHARACTERISTICS OF LIVING ORGANISMS

As previously noted, when studying the human body, it's imperative to remember that it's a living organism. The human body must be distinguished from non-living objects, not simply for mere classification purposes, but for a proper and systematic understanding of the dynamics regarding the actual anatomy and physiology involved in the human body.

Six characteristics said to be required of livings organisms are discussed below.

All living things are composed of one or more cells. All organisms start from a single cell, which will divide several times until differentiation is completed, where the cell's form and function change – producing various kinds of cells to carry out diverse purposes within the organism.

Note: Viruses are a debatable omission; they are not composed of cells, but rather exist and function in a "host" cell. However, they are still classified as living organisms.

All living things are organized.[1] The complexity of a living organism is assembled from microscopic, albeit structured levels, grouping common forms and functions together. Macroscopically, they become observable as the cells are structured to allow for the most physiological sense of the organism. Here, another essential premise in anatomy and physiology should be made: Form always follows function, meaning that organisms are structured conducive and according to how they work – not vice versa.

All living organisms require the use of energy.[2] A chemical process by which nutrients are absorbed and converted into energy to be used at the cellular level is called *metabolism*. This energy is needed to perform each and all of the cell's functions. The human body cannot produce all of the required nutrients organically, and therefore, must ingest nutrition from other sources for this purpose.

All living organisms grow and develop.[3] Each cell undergoes a cell cycle, where it grows and divides to form another indistinguishable, duplicate cell. Following specific instructions from the organism's DNA, or genetic code, differentiation transforms an organism's cells into different types, making a more complex organism. Development is the growth, maturation, and transformation of an organism.

All living organisms reproduce. Reproduction is essential to the prolongation of a species existence. In sexual reproduction, there is a joining of the DNA of two organisms at the cellular level. Sexual reproduction is the form in which the human species reproduce.

All living organisms must possess a normal and stable internal environment; this process is called homeostasis.[4] The internal environment is a matter of physiologic components that include temperature, water regulation, pH balance, heartbeat, sleep, energy, and blood pressure, as well as other conditions. Homeostasis is preserved through a complex system of checks and balances in human beings which is discussed further.

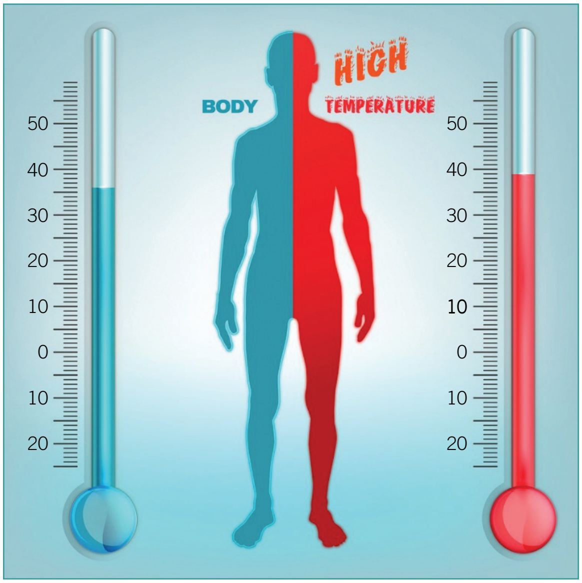

Figure 1-2 Homeostasis.

Homeostasis

Homeostasis is defined as maintaining a normal, stable, internal environment. The human body directs a multitude of highly complex interactions in order to sustain balance or to return its operating organ systems to their normal, standard level of functioning. These complex interactions facilitate compensatory changes accommodating the physical and psychological functioning needed for survival.

All homeostatic mechanisms have at least three separate but codependent modules for regulating and controlling the variables involved in their respective homeostatic processes.[5]

The "***receptor***" is the sensing module that oversees and reacts to changes in the internal environment. When the receptor senses a stimulus, it responds by sending the appropriate information to a second module, the "***control center***" (the brain in humans).

The control center sets the scope of which a variable is maintained and regulates an appropriate response to the stimulus, which signals the third module, an "***effector***", to correct the abnormality by either augmenting it with positive feedback or diminishing it through negative feedback.

For example, when body temperature rises due to external environment, the nervous system triggers blood vessels to dilate and sweat glands to secrete. Under comfortable condition, sweat glands might secrete half a liter of sweat daily. On a hot day, sweat glands can secrete as much as 12 liters per day. It's the evaporation of sweat from the surface of the skin that cools the body through dissipation of body heat.

Mechanisms involved in homeostatic controls, such as body temperature controls, are known as positive or negative feedback.

Positive feedback

Positive feedback mechanisms are intended to promote or enhance the body's response

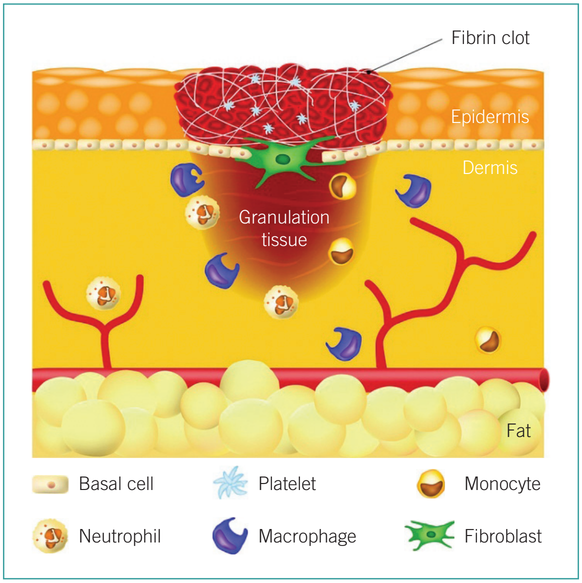

Figure 1-3 Wound healing.

to a stimulus that has already been activated. Contrary to negative feedback mechanisms, which initiate a response to return physiological functions within the body's set and normal range, the positive feedback mechanisms are actually designed to force and keep physiologic functions out of normal ranges.

In order to accomplish this, a sequence of events triggers a respective physiological process through a cascading progression that enhances the effect of the stimulus.

One example of a positive feedback loop mechanism that can be observed in the body is platelet accumulation during a blood clotting episode in response to a break or cut in the lining of blood vessels.

Another example is the release of the hormone oxytocin, which triggers uterine contractions in a female in order to promote the delivery of a newborn that takes place during childbirth. Oxytocin also influences breast milk secretions.

Negative feedback

Negative feedback mechanisms exist and operate to decrease activity of any organ or organ system in an effort to revert it to its normal range of functioning.[6] A great example and common method of doing this is the regulation of blood pressure. Stretch receptors in blood vessels can sense an increase in the resistance of blood flow against the walls during a period of increased blood pressure.

The blood vessels, acting as receptors, receive the increased pressure as a stimulus and signal this message to the brain, the control center. The brain then transmits a message to the heart and blood vessels, both of which then respond as effectors. The heart rate decreases and vasodilation (expansion in blood vessel diameter) occurs. The combination of this physiologic response would cause the blood pressure to decrease and return within its normal range.

The opposite occurs during a sudden decrease in blood pressure; blood vessels now sense the decrease in resistance and signal the brain, which relays the message back to the heart and blood vessels. The heart rate would increase, and vasoconstriction (narrowing of the blood vessels) will occur – ultimately raising blood pressure back to its normal physiological range.

Another excellent example of the negative feedback loop mechanism is seen when the human body is deprived of nutrition. The body, in protective mode, will reset the metabolic rate to a point much lower than its norm. This approach allows the body to continue to function and complete all of its normal necessary physiological functions, albeit at a slower rate, even though the body is starving.

This is why people who drastically reduce their caloric intake while trying to lose weight find it easy to lose the weight initially, but notice it becomes much harder to lose more weight after some time passes. This is due to the body readjusting itself to function at a lower metabolic set point in order to allow for survival than with a lower than normal supply of energy. Exercise increases the body's caloric expenditure, and can alter this effect by exogenously increasing the metabolic demand.

One simpler, yet effective example of the negative feedback mechanism is temperature regulation. The hypothalamus, which monitors the body's temperature, is highly proficient at detecting even the slightest deviation of normal body temperature (37°C/98.6°F). The response to such deviation would be stimulation of sweat glands to produce sweat in an effort to reduce temperature by the cooling effect of evaporation, or signaling various muscles in the body to contract rapidly, or shiver, in an effort to produce heat and increase body temperature.

Both feedback mechanisms are correspondingly essential for normal healthy functioning of the human body. Complications, disease, aging processes, and even death can occur if either of the two feedback mechanisms are distorted in any way.

ORGANIZATION OF THE HUMAN BODY

The human body contains two *major* body cavities – the ventral cavity and the dorsal cavity.

These two cavities are further subdivided and structured to organize and classify the body's internal organs.[7]

Body cavities

The dorsal cavity contains two sub-cavities, the cranial cavity and the spinal cavity.

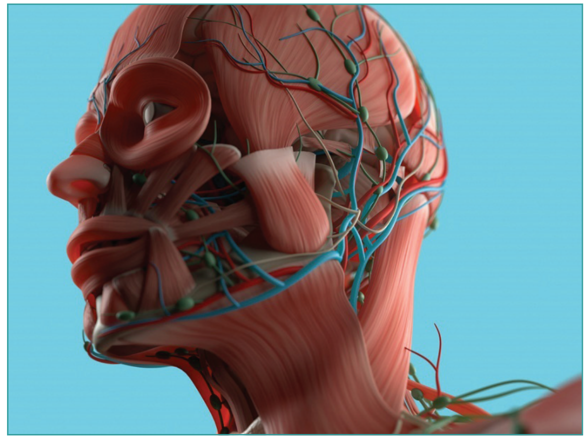

Figure 1-4 Muscle, nerve, and blood vessel connections.

Technically speaking there is no anatomical division as the cranial cavity flows directly into the spinal cavity. However, they are separated into two distinct cavities to assist in study and analysis.

The cranial cavity is a fluid-filled spaced inside the skull occupied by the brain. The spinal cavity encompasses the spinal cord, which travels down the posterior aspect of the body and is continuous with the cranial cavity (the spinal cord is attached directly to the brainstem), extending down toward the base of the spine.

The ventral cavity also includes two sub-cavities, the thoracic cavity and the abdominopelvic cavity. These two cavities are separated anatomically by the diaphragm, with the thoracic cavity residing above the abdominopelvic cavity.

The ***thoracic cavity*** holds the heart, lungs, thymus, lower one-third of the esophagus, and an irregularly shaped, central compartment called the mediastinum.

The ***abdominopelvic cavity*** is further subdivided in some texts into the abdominal cavity and the pelvic cavity, with the caveat that there is no real anatomical partition separating the two cavities.

The abdominal portion contains both the main and accessory organs of digestion (stomach, small and large intestines, liver, pancreas, and gallbladder), as well as the kidneys and ureters. The pelvic portion is surrounded and guarded by the pelvic girdle, and encloses mainly the reproductive organs and the bladder.

Serous membranes

At this point, discussion of serous membranes, also called serosa, of the ventral cavity is appropriate. A membrane is a thin, flexible lining of tissues that secretes a lubricating fluid. Serous membranes form the lining that insulates each body cavity and all internal organs.[8] The membrane itself is composed of two types of tissue – a superficial epithelial layer, called the mesothelium, and a deeper layer composed of connective tissue.

The epithelial layer is a single layer of simple squamous epithelial cells that have no blood supply. This layer is responsible for secreting the lubricating serous fluid. The deeper, second layer is composed of connective tissue, appropriately named the connective tissue layer, which provides vascular and nerve supply to the epithelial layer. The connective tissue layer also functions to bind the membrane to organs and cavities.

When a serous membrane covers and lines an organ, it is generally called a ***visceral*** membrane. When it covers and lines a body cavity, it is generally called a ***parietal*** membrane.

Note: Serous fluid is secreted and lubricates the space that exists between these two membranes.

Specific names are given to serous membranes in the ventral cavity when the membrane covers and lines a particular organ or cavity. For example, the serous membrane that coats the thoracic cavity is called the *parietal pleura. Parietal* distinguishes that it is referring to a cavity, and *pleura* distinguishes that it is referring to the thoracic cavity. Moreover, the serous membrane that lines the surface of each lung, which of course is an organ, is called the *visceral pleura*.

The term *visceral* distinguishes that it is referring to a particular organ – the lung – the term *pleura* again distinguishing that it remains located in the thoracic cavity. The area flanked by these two cavities, called the pleural space, is lubricated with serous fluid to protect the linings from the friction caused by the expansion and contraction of the lungs during breathing. This is similar to engine oil lubricating the cylinder within which a piston pumps up and down during internal combustion of a gasoline engine.

Another specific serous membrane is the lining or covering of the heart, called the *visceral pericardium.* The serous membrane that coats the pericardial cavity (the area that encases the heart) is called the parietal pericardium. (Remember that the term *visceral* defines the membrane that is covering an internal organ, and the term *parietal* means that the membrane is lining a cavity.)

In an effort to reduce the friction caused by the heart pumping inside its cavity, there exists a space joining these two membranes where another serous fluid is secreted.

The abdominal cavity is lined with a serous membrane called the ***peritoneum***. The membrane overlaying each abdominal visceral organ is called a *visceral peritoneum*, whereas the *parietal peritoneum* is the membrane that insulates the entire abdominal cavity. The region conjoining these two membranes is called the

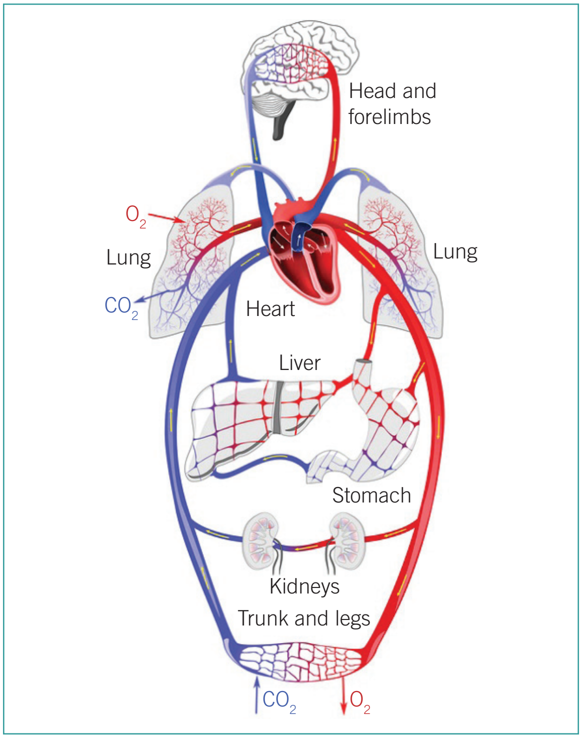

Figure 1-5 Circulation overview.

peritoneal cavity, which too, is lined with serous fluid for lubrication purposes.

ORGAN SYSTEMS OVERVIEW

The human body is made up of several organ systems that function together as one complex unit. Traditionally, the body is divided and studied in eleven different organ systems. Below is an overview of those organ systems, each with the respective structures involved and a brief description of the functions they perform.

Circulatory system

The body's circulatory system, sometimes called the cardiovascular system (in an effort to distinguish it from some texts who include the lymphatic system as part of the circulatory system), is formed by the heart, blood, and blood vessels.

For our purposes, the anatomy and physiology of the body's lymphatic system will be discussed separately in a later chapter.

The cardiovascular system's main function is to pump blood, delivering oxygen and essential nutrients to all living cells via the channels of blood vessels throughout the body.

The heart's *cardiac output*, or volume of blood that is pumped per minute, is an excellent way of measuring how well the heart is functioning.

The three main types of blood vessels, which are discussed in greater detail later, are the arteries, veins, and capillaries. The main component of the human body's circulatory system, the cardiovascular system, is a closed organization, meaning that the blood never leaves the network of blood vessels. Instead,

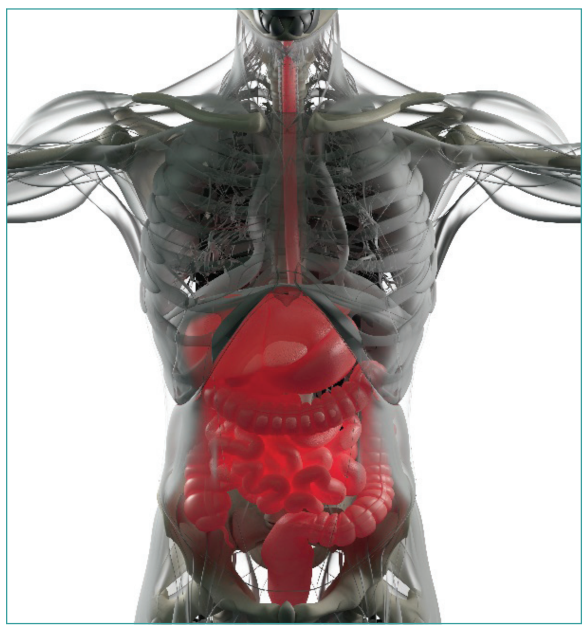

Figure 1-6 Digestive organs.

nutrients, gases, and hormones diffuse across the membrane of the cells in the capillaries and flow into the interstitial fluid (essentially lubricates cellular structures, filled with components such as amino and fatty acids, sugars, and regulatory substances), where they are passed along to target tissues and ultimately the target cells.

Digestive system

The digestive system, or gastrointestinal system as it's sometimes called, is formed by the *major organs of digestion* – the stomach, small and large intestines, and rectum **plus** the *accessory organs of digestion* – the teeth, salivary glands, liver, gallbladder, and pancreas. Each of these organs will be described in greater detail in Chapter 10: *The Digestive System*. Also included are the mouth (oral cavity), esophagus, and anus. Together, these structures function to digest food and excrete waste.

Digestion is the mechanical and chemical breakdown, or catabolism, of food into smaller macronutrients so that they are more readily absorbed.

Mechanical digestion is initially performed by the teeth through chewing. Chemical digestion is initially started by the secretion of saliva, which contains various enzymes (such as amylase) that begin to break down food as soon as it enters the oral cavity.

As food is passed into the esophagus and into the stomach, hydrochloric acid and enzymes continue the chemical digestion process of food breaking it down into a thick liquid known as chyme. Chyme will eventually make its way to the small intestine, where a majority of the nutrients are absorbed, then pass through the large intestine, and finally be excreted as waste material from the rectum and anus by defecation.

Endocrine system

The endocrine system is an organization of glands which regulate various functions in the human body through the use of chemical compounds.[9] These chemical compounds or messengers are called hormones. They act as an information signaling system similar to the body's nervous system.

In contrast to the nervous system, the endocrine system's effects are initiated in a much slower and gradual manner though their effects are longer lasting, sometimes prolonged over a period of weeks.

The *endocrine* system, which is ductless, must be distinguished from the *exocrine* system, which secretes its chemicals through ducts. Exocrine glands secrete onto the skin or into a body cavity, such as sweat.

Hormones are released from endocrine glands directly into the bloodstream and travel to target tissues to generate a specific response. They regulate metabolism, growth

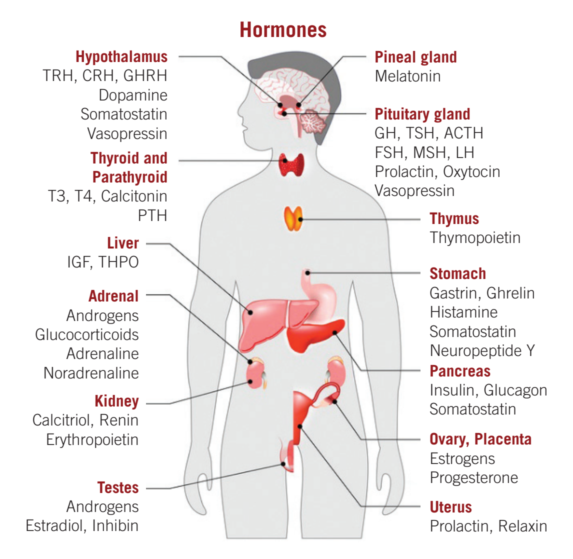

Figure 1-7 Hormone (endocrine) system.

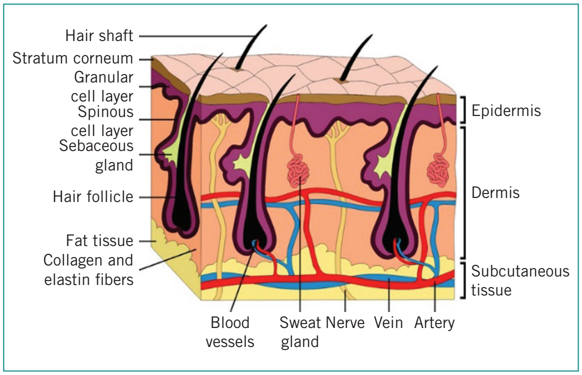

Figure 1-8 Skin anatomy.

and development, tissue function, sexual development, and mood.

The physiological levels of hormones and the functions they perform are age-dependent and change over the course of an individual's lifespan.

Specific glands and secretions will be further detailed in Chapter 13: *The Endocrine System*. Some of the glands involved in the endocrine system include the:

- Pituitary gland
- Pineal gland
- Thyroid gland
- Parathyroid glands
- Adrenal glands
- Hypothalamus

In addition to these glands, the body contains many other organs that have secondary endocrine functions, such as the heart, kidneys, reproductive organs, stomach, pancreas, liver, and intestines.

Integumentary system

The integumentary system is composed of the skin, hair, and nails. The name is derived from its Latin origin *integumentum*, which meant "to cover". The skin, hair, and nails do in fact cover the body, as one of its major functions is to serve as a protective barrier against germs, heat or cold, and help cushion internal organs against injury. The integumentary system also functions to:

- regulate temperature
- receive external stimuli such as pressure, pain, and vibration
- aid in the synthesis of vitamin D from sunlight exposure

The skin is known to be the largest organ of the human body, as it comprises approximately fifteen percent of total body weight.[10] The skin is organized into two layers, called the epidermis and the dermis.

The outer layer, the epidermis, is a major abneural and avascular layer of stratified squamous epithelial cells, which are further organized into five minor layers, or *strata*[11]:

- Stratum corneum
- Stratum lucidum
- Stratum granulosum
- Stratum spinosum
- Stratum basale

It receives nourishment from the lower major layer, the dermis.

The dermis is composed of what anatomists refer to dense irregular connective tissue, called collagen and elastin.

These tissues allow for both the integrity and the flexibility of the skin. The dermis also has a nerve and vascular supply, and is the base for the other structures in the integumentary system, such as the hair and nails.

It should be noted here that some texts refer to the skin as having "three" layers. These texts are referring to a layer deep to the dermis, called the *hypodermis*. Technically speaking, however, the hypodermis should not be included as a segment or layer of the skin, nor part of the integumentary system.

The hypodermis, also called the subcutaneous layer, is primarily composed of adipose tissue or body fat. Its primary function is simply insulation and storage of energy.

Immune system

The immune system is a multifaceted biological system of structures and processes that serve to protect the human body from disease.[12] The primary structures that form the immune system are the bone marrow and the thymus gland. Organs and functions of the immune system will be discussed in further detail in Chapter 8: *The Lymphatic and Immune Systems*. The secondary structures are:

- Lymph nodes
- Tonsils
- Adenoids
- Spleen
- Leukocytes (white blood cells)

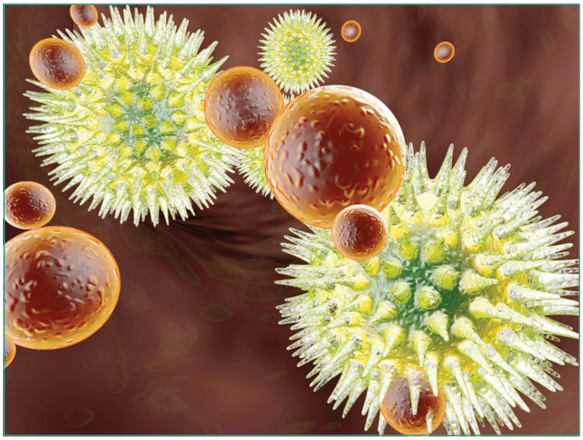

Figure 1-9 Immune system cells.

These structures function together to produce a wide array of defensive mechanisms that serve to protect the human body from a diverse population of pathogens, or infectious agents. The human body's immune system can be classified into two components: *natural* immunity and *acquired* immunity.

Natural immunity, also termed the innate immune system is the dominant defense component of the human body's immune system.

It is a general, non-specific defense system that does not target specific pathogens, but rather responds to invading pathogens in an immediate and universal "attack-all" approach.

Individual elements of the innate immune system include the body's inflammatory response, the "complement system", and leukocytes, or white blood cells. Acquired immunity, also called the adaptive or specific immune system, is activated by the innate immune system to mount a highly specialized immune response, capable of recognizing, targeting, and remembering specific pathogens. This system is dynamic and adaptable, and has the ability to mount a stronger, more specific immune response due to its immunological memory.

Cells of the adaptive immune system "remember" specific pathogens. If such pathogens enter the body more than once, these "memory cells" quickly recognize and target the respective pathogens and eliminate it. Individual constituents of the adaptive immune system include specific leukocytes called lymphocytes (B cells and T cells), as well as antiantibodies, also called immunoglobulins. For example, vaccines induce adaptive immunity.

While an exceptionally complex and highly specialized system, the human body's immune system is not without fault; disorders of the immune system are the reason for allergies, hypersensitivity reactions, autoimmune disorders, tumors, and other devastating diseases.