UNIT 1

INTRODUCTION TO THE HUMAN BODY

Main Concept of the Course

Anatomy deals with the structure and the relationships among the various structures of the body. **Physiology** deals with how the body works. **Physiology** explores the mechanisms by which the organisms control their *internal environments* regardless of what is happening in the *outside* (or *external*) *environment*. Physiology also attempts to explain the physical and chemical factors responsible for both normal function and disease.

Level of organization

The Levels of structural organization from smallest to largest are Chemical (atoms and molecules), Cellular (basic units of the organism), Tissue (groups of similar cells that function together), Organ (structures that are composed of two or more tissues, have specific functions, and usually have a recognizable shape), and System (groups of related organs that have a common function). The cell is the smallest living unit. Everything that is smaller than the cell cannot reproduce by itself.

Atoms and elements link to form molecules. Molecules make up macromolecules, which can form cellular organelles. The cell is the smallest unit of structure that is capable of carrying out the processes of life. Collections of cells form tissues and tissues form the structural units of organs. Almost all cells of the body contain similar organelles like the nucleus, the cell membrane, proteins, and so on. Some cells have taken these basic structures and have turned them into highly specialized structures. These specialized structures give each cell in the body a specific purpose. For example, muscle cells contain large quantities of special proteins that cause the muscle to contract.

When groups of cells that all have the same specialization are grouped together, they are called a tissue. For example, muscle tissue is specialized because it contains cells that can contract. When two or more types of tissues are combined to form a complex, functional unit, they are called organs. For example, the heart is composed of connective tissue, muscle tissue, and specialized conducting tissue. When several organs cooperate for a common function, we call them organ systems. When you combine blood vessels (veins, arteries, and capillaries) and the heart, for instance, you get the cardiovascular system. All of the organs unite to form an organism. In an integrated system, physiology affects many levels of organization. The human body has ten organ systems: integumentary, musculoskeletal, respiratory, digestive, urinary, immune, circulatory, nervous, endocrine, and reproductive.

ORGAN SYSTEMS

SYSTEM	FUNCTION
Integumentary	Protection, water retention, thermoregulation, Vitamin D synthesis
Skeletal	Support, movement, protective enclosure of internal organs, blood formation, electrolyte and acid-base balance
Muscular	Movement, stability, control of body openings, heat production
Nervous	Internal electrical communication and coordination, sensation
Endocrine	Internal chemical communication and coordination
Cardiovascular	Distribution of nutrients, oxygen, wastes, hormones, electrolytes, heat, immune cells, and antibodies; fluid, electrolyte, and acid-base balance
Lymphatic	Recovery of excess tissue fluid, detection of pathogens, production of immune cells, defense
Digestive	Nutrient breakdown and absorption; liver has many functions
Respiratory	Absorption of oxygen, discharge of carbon dioxide, acid-base balance, speech
Excretory	Elimination of wastes, regulation of blood volume, control of electrolyte, fluid and acid-base balance
Reproductive	Continuation of the species

When one thinks about it, none of the chemical constituents of our bodies is alive. Put them together and they still are not alive. What then is life? The Characteristics of Life that determine whether or not an organism is alive are listed in the table below. Life is not a single property, but a collection of properties that distinguish it from nonliving things. Organisms do not have to these things at the same time, but should have those capabilities at sometime during their life cycle. The requirements of organisms to survive are water, food, oxygen, heat, and pressure.

Characteristics of Life	
Organization	Living things exhibit a higher level of organization than nonliving things and spend a good deal of energy maintaining that organization.
Cellular composition	Always compartmentalized into one or more living cells
Metabolism & Excretion	Living things take in molecules, change those molecules to aid them in living and excrete waste materials from the chemical reactions that occur.
Responsiveness & movement	This refers to the ability to sense and react to stimuli throughout all levels of the body. Living things have the ability to propel themselves from place to place.
Homeostasis	Maintenance of a stable internal environment no matter what the external environment is doing.
Growth & Development	Compose of differentiation of cells into specialized organs and growth in size.
Reproduction	Being able to produce a copy of oneself.
Evolution	Exhibit genetic change from generation to generation.

Homeostasis

Homeostasis is defined as the maintenance of relatively stable conditions within the internal environment, regardless of what is happening in the external environment. Homeostasis maintains the optimum concentration of gases, nutrients, ions, temperature, and water. Homeostasis has an optimum volume for the health of the cells. Stress is a factor the affects homeostasis. Throughout this course, we will continue to come back to the theme of homeostasis many times.

The body maintains homeostasis using negative and positive feedback control mechanisms. These feedback mechanisms rely on two control systems to function properly: the nervous system and the endocrine system. Negative feedback control systems are found throughout the body and perform different functions, from maintaining body temperature to maintaining body fluid volumes. The nervous system (brain, spinal cord, and all of the nerves) is especially adapted for rapid communication through its complex system of neurons and nerves. The endocrine system responds more slowly, communicating by the release and distribution of hormones in the blood. We will be examining these two systems as we go along, so it is important to understand how feedback systems work.

All negative feedback control systems operate the same way to maintain homeostasis. They contain a set point, a control center (also called an integrator), an effector, a controlled variable, and a sensor (also called a receptor). Homeostasis has an optimum temperature. Homeostasis has an optimum volume for the health of the cells. If change results in a loss of homeostasis, the organism will attempt to compensate for the changes. Failure to maintain homeostasis can lead to illness, disease or death. If compensation succeeds, the organism returns to a state of wellness.

A **negative feedback system** reverses the original stimulus whereas positive feedback system enhances the original stimulus. The steps for a negative feedback system are listed below.

- The nervous system, via receptors, monitors changes and the status of the body and send inputs to the control center.
- A control center determines the point at which a controlled condition should be maintained.
- If necessary, effectors receive information from the control center and produce a response. The endocrine system releases hormones to maintain homeostasis. The muscular system produces a movement. One thing is certain; disruption of homeostasis can lead to disease and death.

The usual example given in all physiology books revolves around how negative feedback controls body temperature. The set point for body temperature is 37°C (98.6°F). This is the "normal" temperature that you want your body to maintain. Your actual body temperature could be different; it could drop on a cold day to 35°C (95°F). This actual body temperature would be detected by sensors in the nervous system which would signal a control center in a specific region of the brain called the hypothalamus. The control center would notice a difference between the

set point (what you want) and the actual value of 35°C (95°F). The control center would then activate organs and systems (the effector) to generate heat (the controlled variable) by shivering and conserving heat by decreasing blood flow to the skin. Once the body temperature rises back to 37°C (98.6°F), the control center would stop the shivering and would return the blood flow to the extremities. The opposite would happen if body temperature increased above the set point. The sensors would detect the rise in temperature and signal the hypothalamus. Utilizing the nervous system, the hypothalamus would signal blood vessels in the skin to dilate and sweat glands to sweat. Heat would dissipate and body temperature would drop to normal.

Unlike negative feedback systems where the controlled variable eventually shuts off its own production, a positive feedback control system is a mechanism where the controlled variable actually stimulates its own production. Positive feedback systems are self-amplifying mechanisms that can produce a very rapid change in a physiological system. In this system the controlled variable is detected by the sensor that signals the control center to activate the effector to produce more of the controlled variable. In this way, large amounts of the controlled variable are produced very rapidly. Positive feedback systems can exist in the body and are likely to strengthen the response. Occasionally they can lead to a disease state or even a life-threatening situation. The rare instances where positive feedback loops exist in the body and are "normal" are in normal childbirth (oxytocin release) an in the coagulation cascade.

ORIENTATION OF THE BODY - ANATOMICAL POSITION

The anatomical position is a stance in which a person stands erect with feet flat on the floor, arms at their sides, and palms, face, and eyes facing forward.

PLANES OF THE BODY

Midsagittal or median: vertical plane that divides the body or organ in two.
Parasagittal: vertical plane that divides the body or organ into two unequal parts.
Frontal: divides body or organ into anterior and posterior portion.
Horizontal (transverse) divides body or organ into equal superior and inferior portions.
Oblique: passes through body or organ at an angle.

DIRECTIONAL TERMS: indicate relationships of one part of the body to another
Superior: toward the head or the upper part of the body
Inferior: away from the head or toward the lower part of a structure
Anterior: nearer to or at the front
Posterior: nearer to or at the backbone
Medial: Nearer the midline
Lateral: farther from the midline
Intermediate: between two structures
Ipsilateral: on the same side of the body
Contralateral: on the opposite side of the body

Proximal: nearer to the attachment of an extremity
Distal : further from the attachment of an extremity
Superficial: toward the surface of the body
Deep: away from the surface of the body

SURFACE ANATOMY

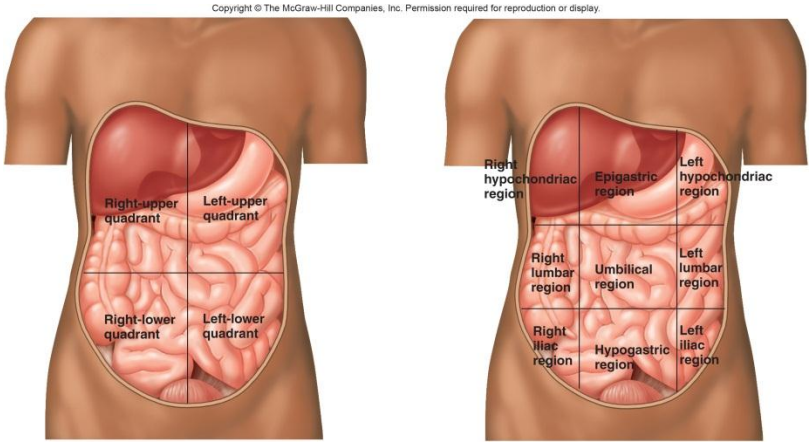
Knowledge of landmarks on the surface anatomy can aid in the identification of internal structures. Below is listed the common name and corresponding anatomical name. We will learn all of the anatomical names and more.

Common name	**Anatomical name**	**Common name**	**Anatomical name**
head	Cephalic	fingers	Digital
skull	Cranial	navel	Umbilical
face	Facial	hip	Coxal
eye	Orbital	back	Dorsal
ear	Otic	loin	Lumbar
nose	Nasal	buttock	Gluteal
mouth	Oral	pubis	Pubic
neck	Cervical	thigh	Femoral
shoulder	Acromial	anterior knee	Patellar
chest	Thoracic	posterior knee	Popliteal
breast	Mammary	calf	Crural
armpit	Axial	ankle	Tarsal
upper arm	Brachial	toes	Digital
lower arm	Antebracial	sole of foot	Plantar
wrist	Carpal	heel	Calcaneal
palm	Palmar		

To see an anterior view of the body, link here or here for a posterior view of the body.

BODY CAVITIES AND MEMBRANES

The body can be divided into a number of spaces called cavities. These separate the body into specific areas. The two main cavities are the dorsal cavity which contains the cranial and vertebral cavities and the ventral cavity. The ventral cavity contains the thoracic cavity (Right/Left pleural, pericardial) and the abdominopelvic cavity. The abdominopelvic cavity can be divided into nine regions by drawing four lines. These



regions are the right hypochondriac, epigastric, left hypochondriac regions at the top; right lumbar, umbilical, left lumbar regions in the middle; and right iliac, hypogastric (pubic), left iliac regions in the lower area. Sometimes the abdominopelvic region is divided into four quadrants by drawing a horizontal and vertical line through the umbilicus creating the right and left upper lower quadrants.

Membranes
Mucous Membranes (mucosa) line body cavities that open directly to the exterior of the body. They line the entire gastrointestinal tract, respiratory tract, reproductive system, and most of the urinary tract. Basically they consist of an epithelial layer that overlies the connective tissue. Serous membranes line closed cavities and cover organs. Synovial membranes line the cavities of freely moving joints.

Rise of the Scientific Method

In an effort to support natural phenomena other than a mixture of belief, superstition, and argument a method had to be developed that was not based on prejudice. Two types of reasoning are applied; an **inductive approach** whereby the scientist accumulates data and then formulates a hypothesis to account for those facts; and a **deductive approach** whereby the scientist constructs a hypothesis, tests its validity outlining particular events that are predicted by the hypothesis, and then performs experiments to test for those events. In time hypothesis gives rise to a theory (a collection of statements or concepts that explains a natural phenomenon. At some point in time a theory becomes a law. Most physiological knowledge was obtained by the hypothetico-deductive method. Usually a hypothesis is in an "if-then" statement. A researcher will state, "If my hypothesis on _____ is correct, and I record my observations during the _____ experiment, then I should observe _____ results." The researcher will design her experiment with enough of a sample size to generate meaningful results, include a control group along with the test group to see if the experiment produced any differences. Results will be analyzed statistically to determine differences.

Why is this chapter important?

The first chapter introduces us to the language or terminology of anatomy and physiology. For us to really learn Anatomy and Physiology, we need to know the terms, descriptions, and meanings of the words of this science. Think of a situation that may occur during your career in which it will be necessary that you describe the anatomical part exactly and its relationship to other tissues in the area.

Throughout this course, the theme of **Homeostasis** will return again and again. Disruptions of homeostasis will trigger feedback systems (a receptor, a control center, and an effector) that will attempt to bring the body back to a normal state. Most feedback systems are negative - kind of like the thermostat in your home. Some others may be positive.

THE CHEMICAL LEVEL

CELLULAR METABOLISM

All cells use energy from their environment to grow, to make new cell parts, and to reproduce. Animals must import energy since they cannot trap the energy of the sun like plants do. Animals extract the biomolecules of energy through respiration which consumes oxygen and produces carbon dioxide and water. Energy is defined as the capacity to do work. In a biological system, work has three forms: chemical work which enables cells to grow, maintain a stable environment, and store information needed for reproduction; Transport work enables cells to move ions and nutrients through the membranes of the cell; and mechanical work which is used for movement. Energy can be differentiated as potential (stored energy) or kinetic (energy in motion). Some kinds of energy are chemical energy (released or absorbed in breaking or forming atoms), radiant energy, and electrical energy. In a biological system, chemical reactions are a means of transferring energy from one part of the system another.

MATTER & ENERGY

Matter is defined as anything that occupies space and has mass. All matter is made from elements. Known elements are listed on the Periodic Table. An atom is the smallest particle of an element that has the properties of that element whereas a molecule is a particle formed by the chemical union of two or more atoms (O_2). A compound is the combination of two or more elements (H_2O).

Atoms join other atoms by forming bonds. When they form these bonds, they gain, lose, or share electrons. Atoms that gain or lose electrons become electrically charged and are called ions. Chemical reactions form or break bonds and in doing so consume or generate energy. Atoms are composed of proton, neutrons, and electrons. Protons have an electrical charge of +1, neutrons have no electrical charge, and electrons carry a charge of -1. An element is characterized by the unique number of protons in its nucleus. The mass of an atom is determined by adding the number of protons and neutrons in its nucleus.

There are eleven essential elements. These are necessary for life to exist. Elements that exist in large quantities are known as major elements whereas those that exist in low quantities are known as trace elements. Trace elements usually are considered minor essential elements and are only recognized when the organism lacks them in their diet. An atom is the smallest particle of an element that has the properties of that element whereas a molecule is a particle formed by the chemical union of two or more atoms (O_2). A compound is the combination of two or more elements (H_2O). The molecular weight of a molecule is determined by adding the atomic masses of all its atoms. Atoms form cations when they lose electrons and anions when then gain electrons. A hydrogen bond is a weak bond between molecules or regions of a molecule such as oxygen, nitrogen, or fluorine.

There are four major groups of **biomolecules** or ORGANIC compounds, which all contain carbon, hydrogen, and oxygen. The table below describes the function of the biomolecule.

ORGANIC MOLECULE	FUNCTION
CARBOHYDRATES	Mostly used as energy sources for cellular metabolism. Ex: glucose, glycogen
LIPIDS	Energy source, chemical messengers between cells, membrane component.
PROTEINS	Structure, communication between cells, membrane transport, catalysis, recognition and protection, movement, and cell adhesion
NUCLEOTIDES	Energy source for the cell (ATP), specifies protein structure and replicates itself exactly (DNA), and facilitates protein production (RNA).

Enzymes
Metabolic reactions require energy to start. Enzymes are the biological catalysts that make cellular reactions happen faster without themselves being changed. Enzymes are usually proteins that promote specific reactions. They are required in very small quantities and are not consumed in the reaction process. Enzymes have a specific molecule that binds to a specific site on the substrate. Previously, the lock-and-key model was used to describe the specificity of the enzyme to the substrate. In current theory, an induced-fit model has being proposed. In this model the binding site only attracts the substrate and as the reaction takes place the binding site changes shape to fit more closely to the substrate. Enzymes are usually named according to their substrate with an -ase at the end. Factors that affect the reaction rate can be divided into those that are essential for enzymatic reaction and those modulators that alter the reaction rate.

Essential for enzymatic reaction to occur:

- Some enzymes are made in an inactive form and must be activated before they can catalyze the reaction. For this to happen, a process called **proteolytic activation** occurs in which a portion or portions of the molecule is removed.
- Some enzymes require **cofactors** or **coenzymes** to be activated. Cofactors may be inorganic molecules or non-protein organic molecules. Organic cofactors are called coenzymes. Vitamins serve as precursors to coenzymes.

Modulators include:

- changes substrate binding at the active site include competitive inhibitor (bind to the site blocking the substrate from binding), allosteric modulator changes the active site, and pH and temperature (alters the shape of the enzyme)

- changes ability of the enzyme to decrease activation energy.

The enzyme amount and the substrate concentration are the two main variables that affect reaction rate. If no enzyme is present, the reaction will proceed very slowly. If present, the reaction proceeds proportionately to the amount of enzyme present. Cells control their physiologic processes by regulating enzyme concentration. The reaction rate can reach a maximum because if enzyme is present, then reaction will occur until all binding sites on the substrate are utilized. This is considered the saturation point.

Finally, metabolic reactions can be categorized as:

- oxidation-reduction reactions in which electrons are added or subtracted.
- hydrolysis-dehydration reactions in which water is added or subtracted.
- Addition-subtraction-exchange reactions in which groups are added, subtracted, or exchanged.
- ligation reactions in which two substances are joined using energy from ATP.

INORGANIC COMPOUNDS

The rest of the chemicals involved in the chemical reactions of the cell are inorganic. Of the INORGANIC COMPOUNDS that make up the body, the most important is **Water**. Other inorganic substances include carbon dioxide, oxygen, and some inorganic salts. Water is the most abundant substance in the body. It functions as a solvent and suspension media; it participates in chemical reactions; it releases heat slowly; it requires a large amount of heat to change from a liquid to a gas; and it serves as a lubricant. **Oxygen,** another inorganic molecule, is also necessary for life as it releases energy for metabolic activities.

Solutions and solutes

Substances that dissolve in liquid are known as solutes whereas the liquid in which the solute dissolves is called a solvent and the combination of both is called a solution. The universal solvent is water. However, not all solutes are soluble in water. Those that dissolve readily are hydrophilic whereas those that aren't are hydrophobic. Concentrations of a solution can be expressed in a number of ways: moles or millimoles per liter for most substances in the body, equivalents or milliequivalents if we are discussing ion concentrations, and weight per volume as a percent solution. The concentration of hydrogen ions is expressed in pH units.

What’s important about Acid-Base Balance?

The more hydrogen ions present in a solution the more acidic that solution and the lower the pH. The body’s normal pH is 7.35 - 7.45 (slightly alkaline). To maintain homeostasis, this pH must be maintained. Maintenance is done through buffering systems; usually a weak acid or a weak base that eliminates excess OH- or H+. We’ll discuss buffering systems later in the chapter on acid – base balance.

Why is chapter important?

The chemistry of life is explained in this chapter. You should know the function of water and oxygen, the two most important inorganic molecules that impact the human body. The Organic compounds: carbohydrates, lipids, proteins, and nucleic acids are discussed. Of these, proteins are the most diverse of the biomolecules. The role of enzymes is also explained.