

# **General Physiology Made Ridiculously Simple**

Distilling the principles that make your  
body function, in an exciting way...

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## DEDICATION

This book is dedicated to my students, and all lovers of Physiology — the bedrock of Medicine!

## **ACKNOWLEDGEMENT**

I wish to thank all my teachers and senior colleagues in the Physiology profession who had invested in my knowledge and understanding of the subject.

Also, I wish to thank my wife for her understanding and support during the process of putting pen to paper and making this a reality..

## PREFACE

On one auspicious day at work, a student walked into my office, the Exam Office, and made a rather striking comment. She said my lectures in class were quite easy to understand and interesting, but the note I gave them was more difficult to understand. It was a most valuable feedback, and I decided to do something about it as quickly as possible. This book in your hand is borne out of that decision, to make the written text of physiology lectures as simple and interesting as a good lecture in class.

Furthermore, most popular and available physiology textbooks are for reference purposes — they go far beyond the scope of knowledge required for most undergraduate students, and they are adapted for international readership. Most average students of physiology in our environment find the technical English language and medical jargons presented in those books somewhat confusing. This book removes that barrier, presenting the fundamentals in a very simplified yet elaborate manner. I have no doubt that this book will greatly make a positive difference in the lives of students, especially at the undergraduate level.



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# CHAPTER 1

## INTRODUCTION TO HUMAN PHYSIOLOGY

### LEARNING OBJECTIVES

*After studying this chapter, you should be able to:*

- ✓ Have a basic knowledge of physiology and what it entails
- ✓ Describe the levels of cellular organization and state the four major types of cells and tissues
- ✓ List the various systems of the body and describe their basic functions
- ✓ Know and understand the general principles of physiology

### Definition of Terms

- **Matter:** Matter is anything that has weight and occupies space; this can be either physical, seen, or unseen. The atom is the most basic unit of matter.
- **Energy:** Generally defined as the ability to do work. However, at an atomic level, energy is the ability to attract or repel matter.
- **Cell differentiation:** It is the structural transformation of cells in order to perform a specialized function.
- **Epithelial tissue:** A group of cells with the specialized function of **covering** the surfaces of organs.
- **Physiological variable:** It can be anything that can be measured in the body that is subject to change eg temperature, blood pressure, blood glucose, etc.

**Key Words** 🔍: Deconstruction, components, interactions, underlying principles, chemical reactions.

## Overview

From a biological point of view, what is life? How is life made possible? Life is made possible through an organized interaction between different parts of the body. Physiology is a life (biological) science that studies how the body works or functions to sustain and reproduce life. To do this, physiologists follow a **systematic approach** in understanding the human body. Once you understand and follow the systematic approach and the **underlying principles**, physiology becomes a lot easier to understand. Remember, the course is all about *functions* - how things work in the body.

## Systematic Approach

Before you got to this level, you were trained in secondary school on how to write long essays with several paragraphs. Each paragraph contains a few sentences, each sentence contains a few words, and each word contains a few alphabets. So, before you could ever write a complex essay, you first started with learning each letter of the English alphabet in nursery school. Similarly, to understand how the complex human body functions, physiologists needed to break down the body in bits until they got to the smallest unit. This process is what I call '*deconstruction*'.

**Deconstruction** is the process of separating complex systems into the smallest possible parts and units in order to understand how things work. Instead of trying to understand the system all at once, you break it up into smaller parts and then work on understanding the parts and units, and how they **interact** with one another. To understand how a complex system like the human body works or

functions, you need to first understand the concepts of (1) *components/parts* and (2) *interactions/conversions*.

1. **Component/parts:** You will recall that in primary school, you learnt that every living thing possesses about eight or nine basic characteristics, popularly remembered with the acronym MR NIGER D - **M**ovement, **R**espiration, **N**utrition, **I**rritability, **G**rowth, **E**xcretion, **R**eproduction, and finally, **D**eath. You also learnt that the **cell** is the smallest unit of life, which means that the cell is the smallest structure that possesses all the basic characteristics of a living thing. Therefore, when you break down the human body, the smallest component is the cell. It is only from the cell that you can sufficiently understand how the body functions. The human body is made up of trillions of cells.

**Key Insight** 💡: To understand the whole, look at the parts; to understand how the parts relate, look at the purpose!

It is no surprise therefore that the life of a human being starts as a single cell in the uterus (womb) of the mother. It becomes more complex by dividing and multiplying into numerous cells. Some cells begin to change their shape and structure, and so their function is also changed. This is known as **cell differentiation**. Cells with similar structure and function combine to form **tissues**. Tissues are broadly divided into four categories: **muscle tissue**, **nervous tissue**, **epithelial tissue** and **connective tissue**. One type of tissue combines with other types of tissues to form **organs**, such as the heart, lungs, and kidneys. Therefore, an organ is a structure that has different tissues performing different functions all for **the same purpose**. For example, the heart as an organ has different types of tissues which cooperate and interact with one another all for the single

purpose of pumping blood into blood vessels. Finally, two or more organs functioning differently but for the same purpose make up **organ systems**, or simply **systems**. For example, the blood vessels (arteries, arterioles, capillaries, venules and veins) help to distribute the blood that the heart has pumped under pressure to all parts of the body. Together, they are called the Cardiovascular System. The various systems of the human body include:

- I. Nervous system: Made up of the brain and spinal cord. It deals with response to stimuli (irritability).
- II. Cardiovascular system: Aka circulatory system. Made up of the heart and blood vessels. Its purpose is to pump blood under sufficient pressure for distribution to all parts of the body.
- III. Respiratory system: Made up of the nostrils, pharynx, larynx, trachea, bronchi, bronchioles and alveoli. Responsible for inhalation, exchange and exhalation of  $O_2$  and  $CO_2$ .
- IV. Digestive system: Aka gastrointestinal system. Made up of the mouth, oesophagus, stomach and intestines (small and large). Responsible for nutrition (ingestion, digestion and absorption of food substances).
- V. Urinary system: Made up of the kidneys, ureters, urinary bladder, and urethra. Responsible for the excretion of metabolic wastes.
- VI. Reproductive system: Made up of the testes, epididymis, vas deferens, prostate gland for the male, and ovaries, fallopian tubes, uterus, vagina for the female. Responsible for giving birth to offspring.
- VII. Endocrine system: Made up of the pituitary gland and many other glands which secrete chemical substances into the blood. Responsible for cell

signalling and communication (chapter 4) in order to coordinate different physiological processes.

- VIII. Musculoskeletal system: Made up of the skeletal muscles and bones. Responsible for movement of the human body with respect to position and location.
- IX. Immune system: Made up of the white blood cells, bone marrow and thymus. Responsible for defending and protecting the body against disease-causing agents.
- X. Lymphatic system: Made up of lymph vessels and lymph nodes. Responsible for collection of interstitial fluid for return to blood, participation in immune defences, and absorption of fats from digestive system.

**Acronym & Mnemonic:** MURDER LINC or **My Roommate Is Extremely Nervous Cos Uncle Dan Lied Recently**

2. **Interactions/conversions:** For a raw material to become a finished product, it must interact and combine with other raw materials, and then be acted upon by a form of **energy**. To prepare egusi soup, you need to get raw egusi, mix it with other ingredients in water, and heat it on fire. That's how it is in the human body. In the human body, millions of **chemical reactions** and interactions (equivalent of cooking or manufacturing) take place within and around the cells of the body. These reactions lead to the physiological functions that we see. Hence, physiology frequently looks at chemical interactions in order to understand function.

**Key Insight** : The body is like a huge construction and manufacturing site with work (chemical reactions)

being done very rapidly, and millions of activities going on non-stop!

## Underlying Principles

*"When you first start to study a field, it seems like you have to memorize a million things. You don't. What you need is to identify the core principles - generally three to twelve of them - that govern the field. The million things you thought you had to memorize are simply various combinations of the core principles" - John T. Reed*

For the study of physiology to really be ridiculously simple for you, you need to first know and understand the general principles which apply to the functioning of all the systems. Once you have done that, you begin to look for how those principles play out when you study a new system. Let us briefly shed some light on these general principles.

### **1. *The body functions through multiple control systems which work in opposition, but are essential for health and survival***

Too much and too little of everything is bad; hence, the body tries to always maintain a balance in different physiological variables. To do this, the body has *control systems* (discussed later) that function like the accelerator and brakes of a car, each in opposition to each other, all in a bid to maintain balance. This balance is known as *homeostasis* (discussed later); so, if there is failure of any control system, then disease results.

### **2. *The functions of organ systems are coordinated with each other***

It is common knowledge that to achieve better results within a system, every member works as a team. It is the same within the body. Sometimes, two or more systems

cooperate to control a single physiological variable, like the case of blood pressure control that involves the nervous, urinary and cardiovascular systems.

**Key Insight** 💡: Teamwork makes the dream work. All systems in the body must cooperate, work together and depend on each other to achieve the overall purpose of the body - health, survival and reproduction!

### **3. *Communication between cells, tissues, and organs is necessary for the integration of physiological processes***

To work as a team, team players must of necessity share ideas, brainstorm and communicate with each other in order for the work to move smoothly. It is the same in the body. There is information generation and communication that goes on between cells, tissues and organs in order for various physiological processes to be well coordinated.

### **4. *Controlled exchange of materials occurs between compartments and across cellular membranes***

The cell being the smallest and functional unit of life, all inflow and outflow of materials must pass through cell membranes. The nature and peculiar characteristics of various cell membranes regulate the amount and type of substances that will pass through it. This of course contributes to homeostasis.

### **5. *Structure is a determinant of function***

*"Descriptive anatomy is to physiology what geography is to history, and just as it's not enough to know the typography of a country to understand its history, so also it is not enough to know the anatomy of organs to understand their functions". - Claude Bernard*

Consider a knife and a spoon; do they perform the same function? Your guess is as good as mine. But first look at their shape and design, does it suit the function which they perform? Certainly! This means that the structure, shape or design of a thing is a pointer to its function. Anatomy deals with the structure and design of the component parts of the body. Therefore, a description of the anatomy of any cell, organ or system sheds light on its physiological functions. However, understanding anatomy alone won't give you enough answers; hence, we will need to depend on the next general principle.

### **6. *Physiological processes are dictated by the laws of chemistry and physics***

*"The body as a whole may, from a chemical point of view, be considered as a mass of various chemical substances..." - Michael Foster*

Behind every physiological action or response, there is a chemical reaction. Chemistry deals with the properties and behaviour of matter, and the changes that occur when different elements and compounds combine with each other in the presence of energy. It is therefore easy to appreciate that since our bodies are composed of matter (atoms and molecules), we will need to observe the behaviour of molecules in a [bio] chemical manner. Also, physical laws help us understand the function of some physical aspects of body functions. For example, the physical laws that govern the relationship between pressure and volume (Boyle's law) help us understand the mechanism of breathing; the laws that govern the relationship between the diameter of a tube and the pressure inside help us understand the regulation of blood pressure.

### **7. *Proteins are the structural and functional molecules in a cell***

Behind every chemical reaction in the body, there is a protein (enzyme). Also, proteins have a very complex structure known as quaternary structure that easily changes during chemical interactions. The change in structure (aka **conformational change**) leads to a certain physiological function, because structure determines function.

**Ponder 1.1** 🤔: How does knowledge of physiology help you as a future health practitioner?

## **Reference Ranges**

Since physiology deals with normal functioning of the body, the values of various physiological variables in healthy people have been determined. These values have a range (lower & upper limit, aka control limit) that is considered normal (reference range), and whenever there is a deviation from this range, the body tries to bring it back to normal. However, when there is a persistent deviation from the reference range, it indicates ill-health. Therefore, knowing these reference ranges in the various systems of the body helps you know when there is a deviation from normal, which indicates a problem. It is therefore important that a student of physiology learns how to measure these values, which is the focus of your laboratory practical sessions.

## **Answer to Questions**

**Ponder 1.1** 🤔: How does knowledge of physiology help you as a future health practitioner?

**Answer to Ponder 1.1:** As noted in the text, health is a function of homeostasis, and disease/ill health a failure of homeostasis and control mechanisms. Therefore, an

**understanding** of physiology, which basically deals with all bodily functions and their control mechanisms, helps you know what to do to **improve** and maintain the health of your patients. You can't improve what you don't understand!