HUMAN PHYSIOLOGY

DR. C. C. CHATTERJEE

MEDICAL ALLIED AGENCY

HUMAN PHYSIOLOGY

VOLUME I

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Dedicated to the Memory of

my

Father and Mother

C. C. CHATTERJEE

PUBLISHERS' NOTE TO THE ELEVENTH REPRINT EDITION

To cope with the fundamental principles of Physiology and to know thoroughly the most common and most serious affections met in daily exercise, to smell danger in time and to determine and treat cases on proper and rational lines some addition has been made in the text.

The very eulogistic welcome accorded to the first edition of HUMAN PHYSIOLOGY by Dr. C. C. Chaterjee which put in its first appenrance in 1951, enjoying steady demand and inquiries with magnificent reception from the teachers and the taught at home and abroad with the progress of the subject the very text book was converted to Volume I & Volume II in the year 1972. The very essence have convinced the Publishers the need for an early publication of the ELEVENTH EDITION OF VOLUME I. to meet the persistent demand of the students and intelleotual concerns. This edition is also composed of lucidity and bravity.

We have the pleasure in offering the students and intellectuals in Medical profession the new advanced conception excellently expressed and modified with data specifically the chapter of Respiratory System by Dr. Hiralal Saha, M. B, Ph. D. (B'ham). And for his valued contribution we accord our gratitude and esteem.

We are thankful to Prof. A. M. Seligman, Dr. Barbara R. Betty and Dr. Davenport for allowing us to utilise a number of illustrations in this volume.

We are glad to express our sincere gratitude to Dr. N. M. Basu, Dr. S. C. Roy and Dr. Mrs. M. Ray for their advice to this text.

We offer our warmest gratitude to the everlasting memory of Late K. L. Chatterjee, ex-principal, City College Commerce and Business Administration whose guidance and contribution to the Publisher placed them in debt, but his character we greatfully count.

We are profoundly thankful to Mr. P. N. Mitter, Solicitor and to our Banker, State Bank of India, Surya Sen Street Branch, for their benevolent aid.

We admire the patience, devotion and the unfailling courtesy of Ashutosh Lithographic Company, New Mudrani and New Indian Process. Our greatful acknowledgements are also due to the many who by their kind co-operation have assisted in the preparation of this edition.

Publishers firmly believe that this eleventh Reprint edition of Volume I of HUMAN PHYSIOLOGY will receive the same reception as before and constructive criticism, defects will be greatfully acknowledged.

Consequential demand of this book, we are compelled to publish this volume as a reprint edition and for the consequential inflation of price index, we are compelled to enhance the price of the book and for which we beg to be excused.

AKHAYA TRITIYA
Dated 1st May, 1987

Sincerly
MAYA CHATTERJEE
ASHOK KUMAR CHATTERJEE
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FROM THE PREFACE TO THE FIRST EDITION

At the outset, I would like to pay my humble regards to my revered teacher, Dr. Charubrata Ray, M. B., B.Sc., from whose lips I learnt how to 'read' and 'think' Physiology. A quiet unassuming man, a scholar with an inborn spirit of research, a teacher of rare genius-teaching thousands of students throughout his life without the least material interest of his own-Dr. Ray represents that long-forgotten school of 'Indian Gurus' with whom teaching was a creed and not a profession. In teaching he sprouts wings. Seldom a teacher could have claimed to have so many students and seldom could he command so much respect from them. There are thousands today who take his name with grateful reverence. May he live long and lead us with his kindly light.

For the last few decades, Physiology has been making so rapid progress that it is being increasingly difficult for the average students to manage the subject within the limited period fixed by the universities. Owing to this reason, they are compelled to go in for 'notes', 'synopses', 'made easies' and such other short-cut devices which somehow enable them to squeeze through the examinations but fail to give them a comprehensive knowledge of the subject as a whole. This state of affairs is cutting at the root of medical education and is likely to undermine the standard Medical graduates. What is required today is a text book of reasonable size, including the essentials of histology, biochemistry and biophysics which will give the student a bird's eye view of the whole subject and at the same time enable him to pass the examination with credit. This book is an attempt in that line.

It has been drawn up to meet the requirements of the preclinical medical students of the different Indian and foreign universities mainly. Advanced and post-graduate students will certainly derive some help from it but should not depend on this book alone. I have no hesitation to say that a good deal of attention has been paid to assure success in examinations. Each system has been divided up into a number of problems in such a way that they are usually set or likely to be set as questions by various examining bodies. At the

beginning of each system a few introductory lines have been added in which the fundamental principles of that system have been discussed. The students are advised to read these portions carefully and thoroughly to have a better grasp of the subject.

I have tried to avoid as much of the applied aspects as possible because it is my experience that a book meant for the pre-clinical students, should not contain much of applied discussions. The beginner only gets confused and tries to cram up the unnecessary applied details, leaving aside those portions more essential for him. The little 'applied' necessary for them should best be left to the teachers.

* * * * *

The 18th July, 1951 C. C. CHATTERJEE

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HUMAN PHYSIOLOGY

VOLUME I

INTRODUCTION

The term *physiology* originated from a Greek root *Physiologikos* meaning discourse on natural knowledge. It was introduced by the French physician Jean Fernel in 1552. Physiology deals with the normal functioning of the body.

Unlike metaphysics, the science of physiology holds that there is nothing 'occult' or 'supernatural' about 'life'. All the living processes of an organism can be explained, or better, should be explained, with the help of the underlying chemical and physical changes and the structural peculiarities. The progress of ancillary subjects, such as physics, chemistry, biology, microscopic anatomy, etc., has given us ample opportunity to apply the principles of these branches of science to the understanding of working processes of the living organism. Consequently, physiology is a tripod science, its three legs being *Physics*, *Chemistry* and *Anatomy*. In order to have a fair knowledge on the subject, one should be well acquainted with the three basic sciences mentioned above. Studies like the circulation of blood or the passage of ions across biological membrane, etc., involve the study of physical processes taking place in the body and is named as *Biophysics*. *Medical statistics* is a branch of science which deals with the evaluation of different experimental data. *Biochemistry* is that branch of science which explains the functions of the body on a chemical basis as might be carried out in a chemical laboratory. The study of structure of an animal is the science of *Anatomy*. Such structure when studied with unaided eye is named *Gross Anatomy* or *Macroscopic Anatomy* and when studied in detail with the help of microscope is called *Microscopic Anatomy* or *Histology*.

It is obvious that all these divisions are only various attempts to approach and understand the same problem from different standpoints. In spite of such endeavour, there are still many aspects of physiology which we fail to understand. But that does not prove the existence of anything 'occult' concerning 'life'. It indicates more probably that our investigations are not adequate enough and that our methods of study are not perfect. In a nutshell, the whole purpose of physiology is to explore the normal functioning of the living organisms—their principles, their mechanism, and their control.

A SYNOPSIS OF PHYSIOLOGICAL STUDY

The functional unit of the body is the *cell* and a group of similar cells constitute a *tissue*, a group of tissues form a *system*. Recently, application of electron microscope and histochemical techniques have revealed quite a complex structure of the cell. The first chapter of this book begins with the functional unit of the body, i.e., the **cell.**

The functions of the body are based on, experimental results and clinical findings. In order to understand the functions of the body, it is convenient to divide them *broadly* into the following systems:

Haemopoietic system; Reticulo-endothelial and Lymphatic systems; Skeletal and Muscular systems; Circulatory system; Respiratory system; Digestive system and Metabolism; Excretory system; Endocrine and Reproductive systems; Nervous system and Special senses.

Haemopoietic System. Haemopoietic system consists of blood in which there are cellular elements and the fluid *plasma*. Total circulating

blood volume is about 8 per cent. of body weight, approximately 55 per cent. of which is plasma. The plasma contains absorbed foodstuffs, metabolic products, enzymes, hormones and many other substances. The cellular elements consist of (*a*) Red Blood Corpuscles (R.B.C.) or *Erythrocytes*, (*b*) White Blood Corpuscles (W.B.C.) or *Leucocytes*, (*c*) Blood Platelets or *Thrombocytes*. Blood is red due to the presence of haemoglobin (*chromoprotein*) inside R.B.C. The main functions of blood are to transport respiratory gases, nutrition, hormones and waste products, etc.

Reticulo-endothelial and Lymphatic Systems. Reticulo-endothelial system consists of reticulum cells, endothelial cells and some wandering cells. The reticulum cells are present in the spleen, lymph nodes and bone marrow, and the endothelial cells are present in the blood sinuses of spleen, bone marrow, etc. The wandering cells are present in the blood stream. The main functions of the cells of this system are phagocytosis, formation of antibodies, formation and destruction of red blood corpuscles, etc.

The lymphoid tissue consists of lymphoid cells, lymphatic channels and the lymph nodes. The lymphoid tissue is distributed throughout the body, viz., lymph nodes, pharyngeal tonsil, spleen, in the mucous membrane of the small intestine known as Peyer's patches, vermiform appendix, etc. The lymphatic vessels are thin-walled channels containing valves so that the lymph can flow in one direction only.

Skeletal and Muscular Systems. Movements of organs and locomotion of the entire body are based on the presence of bones to which muscles are attached constituting a system of lever action. The bones constitute the framework of the body and afford protection to some of the vital organs. They also serve as great reservoir for minerals specially phosphorus, calcium, etc., contain bone marrow which acts as haemopoietic organ and is the chief site of reticulo-endothelial cells. There are two hundred and eight bones in the human body.

Movements are effected by muscles. They cover the bony parts of the skeleton in almost every part of the body, giving the organism its normal external shape. They help in movement of the limbs, locomotion and liberation of heat and energy.

Circulatory System. This system consists of the heart and blood vessels. Heart is situated inside the thoracic cage and consists of four chambers, e.g., two atria and two ventricles. The right atrium receives impure blood through large veins from the upper and lower regions of the body. The right atrial blood through an opening known as *atrioventricular opening* passes into the right ventricle. From the right ventricle arises the pulmonary trunk. The pulmonary trunk divides and breaks up into capillaries in the lungs. Due to contraction of the right ventricle, the blood is carried to the lungs. This course is known as *pulmonary* or *lesser circulation*. In the alveoli of the lungs the impure blood gives off carbon dioxide (CO_2) and takes up oxygen (O_2) and thereby gets 'purified'. The pure blood from the lungs is carried through pulmonary veins to the left atrium and through atrioventricular opening to the left ventricle. From the left ventricle arises a large artery known as the *aorta*. The left ventricle contracts and the pure blood is pumped out to the aorta. The aorta and its arterial branches which break up into capillaries carry the pure blood

to the head and neck regions, superior and inferior extremities, thorax, abdomen and trunk. The impure blood from different regions of the body is carried by the veins provided with valves into the right atrium. This course of circulation is called *systemic* or *major circulation.* The right atrium sends blood to the right ventricle and the cycle is repeated. There are about 5 litres of blood in a normal adult human body. The amount of blood ejected per ventricle per minute is about 5 litres and that is known as *cardiac output.* Heart beats from 70 to 80 times per minute, and the amount of blood ejected per ventricle per beat is about 70 ml.

Respiratory System. It consists of the nasal passage, nasopharynx and oropharynx, laryngopharynx, larynx, trachea, bronchi and two lungs, one on each side. The lungs consist of bronchioles and alveoli. The alveoli are thin-walled and the blood capillaries remain in the partition between adjacent alveoli. Through the endothelial lining of the alveoli and the endothelial lining of the capillaries, CO_2 diffuses into the alveoli and from the alveoli O_2 diffuses into blood remaining in the capillaries. The impure blood becomes pure and is distributed through the arterial system into different parts of the body. Normal average respiratory rate is 18 per minute.

Digestive System and Metabolism. These deal with digestion, absorption and utilisation of food. The process of digestion is carried on with the help of *enzymes* present in the *oral cavity* and *gastro-intestinal* (G.I.) *tract.* The end products of digestion are mostly absorbed from the small intestine and help in the growth and repair of tissues and in the liberation of heat and energy. The unabsorbed food residue is passed out *via* the lower part of the large intestine. In this system, there are glands, e.g., salivary glands, liver, pancreas and other intestinal glands, the secretions of which play a great role in the process of digestion.

All forms of transformation, chemical and energy, taking place in the body, are termed as **metabolism.** The oxidation of foodstuffs which gives away energy is known as **catabolism.** On the other hand, the opposite process, formation, which uses up energy is named as **anabolism.**

Excretory System. There are two kidneys in the abdomen, one on each side of the vertebral column. The upper pole of the left kidney lies between the eleventh and the twelfth thoracic vertebrae and that of the right kidney is at the level of the twelfth thoracic vertebra. The position of the liver makes probably the right kidney to be lower than the left kidney. Each kidney consists of millions of renal units known as nephrons. Each nephron is made up of a glomerulus and tubule. Kidneys excrete end products of metabolic activities of the body and thus they are a main factor in controlling the concentration of the constituents of body fluids, maintaining electrolyte and water balance in tissue fluids. The skin is an another organ through which the waste products are also eliminated. The skin also helps in the regulation of water balance of the body.

Endocrine and Reproductive Systems. There are some glands in the body, e.g., pituitary, thyroid, parathyroid, suprarenal, islets of Langerhans in the pancreas, and the gonads, etc., where certain secretions are not drained out through ducts and as such they are known as *ductless* glands or endocrine (*endo*=internal; *crine*=secretion) glands. Such secretions are known as *hormones* (*horma*=to excite). Hormones

circulate in blood stream and help, in general, skeletal, sexual and mental growth, and carbohydrate, protein, lipid and mineral metabolism, etc. Hormones of some of the endocrine glands help in the regulation of water balance of the body. The gonads, e.g., testes in males and ovaries in females play very important role in the sexual and reproductive activities in males and in females respectively.

Nervous System and Special Senses. It consists of the central or somatic nervous system, the autonomic nervous system, and the special senses. The *central* nervous system consists of cerebrum, cerebellum, brain stem, spinal cord. The ventricles in the cerebrum, brain stem and central canal of the spinal cord contain cerebrospinal fluid. There are 12 pairs of *cranial* nerves and 31 pairs of *spinal* nerves. The central nervous system is mainly concerned with higher intellectual faculties, maintains muscle tone and regulates posture and equilibrium. The *autonomic* nervous system consists of sympathetic and parasympathetic nerves. They control the secreting glands, the involuntary muscles, etc. Hypothalamus is the higher centre for the autonomic nervous system. Besides other functions, hypothalamus plays an important role in the regulation of body temperature and also controls the functions of different endocrine glands. The sense organs mainly consist of **taste, smell, vision,** and **hearing.**