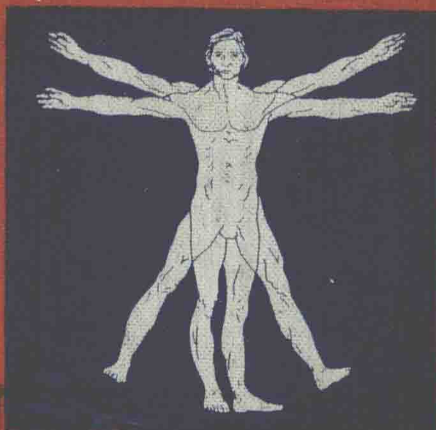
ANATOMY OF THE HUMAN BODY



GARDNER AND OSBURN

ANATOMY OF THE HUMAN BODY

THIRD EDITION

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PREFACE

This book has been created by a physician anatomist, who is also a medical illustrator, and a medical illustrator whose education and experience have given him an extensive knowledge of biology and anatomy. This association has resulted in a verbal-visual partnership in which the words and the illustrations merge into a cohesive entity for the reader.

The purpose of the third edition remains the same as stated in the preface to the first edition: to provide a comprehensive introduction to the structure of the human body for the college and university student who is studying anatomy for the first, and possibly only, time. The continued and increasing use of this book indicates that the authors' original thesis was correct: that there is a need for a text for allied health professions students that meets the requirements of the corps of well-trained faculty members by providing a more extensive foundation in anatomy.

OBJECTIVES

1. To provide an introduction to the gross structure of the human body.
2. To correlate modern information from cell biology, microanatomy, and ultrastructure with gross anatomy to provide a transition from introductory courses in biology.
3. To correlate the simpler forms in the development of the human embryo with the adult as a basis for understanding the complexities of adult structure.
4. To apply knowledge gained of the structural framework of the human body to body function so that learning is more meaningful in terms of how a person lives, works, and plays.

LEARNING PLAN

The reading material has been prepared in accord with a learning plan in which the structure of a human body system or a body part is developed by logical subunits of information that build to a functional whole. The reader is encouraged to use the sectional headings and their subject content as study units. A flow chart of the learning plan, which is part of the instructor's guide, is repeated in the appendix for the student reader.

Third Edition Additions and Changes

New inclusions or changes in this edition are as follows:

1. A new, comprehensive illustration of the cell with details of its organelles to accompany the ultrastructural correlations with cell structure.
2. Shifting of the general information about cartilage and bone from the connective tissue chapter (Chapter Two) to the skeletal-articular chapter (Chapter Four).

3. Insertion of the chapter on the integumentary system and skin earlier (Chapter Three) in consideration of the practice of teachers in their courses.

4. Rewriting of the section on cranial nerves in order to make the account of the distribution of their components to effector tissues more complete.

5. Addition of a new chapter, which, in describing verbally and pictorially the regional composition of selected parts of the human body, can lead the reader to better appreciate that body regions and subregions are assemblages of representative components from human body systems.

6. Addition of end of chapter review questions to enable the reader to evaluate what has been learned.

7. Inclusion of reader's objectives at the beginning of each chapter that describe, generally, what will be the outcome of his or her study.

8. Inclusion of a learning plan flow scheme (see p. 519) that shows the reader how and where concepts of structural importance appear as study units in the book.

9. Addition of a separate instructor's manual to make the text more useful to the teacher as lesson plans are prepared.

10. Redrawing and rephotographing of some of the existing illustrations to make them more effective in imparting information.

Acknowledgments

Faculty associates of the text author at the Medical College of Wisconsin have continued to be helpful and supportive. Critical reading of the manuscript and practical suggestions by Dr. Lowell A. Sether have been particularly sustaining. Dr. Kenneth Siegesmund has added a new electron photomicrograph to his previous examples to be found in Chapter One. Both Dr. F. David Anderson and Dr. Robin L. Curtis reviewed the rewriting of the section on the cranial nerves. Dr. Stanley Kaplan suggested an illustration addition to the embryology section of Chapter One. Both Jeanette E. Brasseur, R.P.T., and Judith A. Landusky, R.P.T., have reviewed the muscular and nervous system chapters in respect to their utility for students in the rehabilitation therapies and made pertinent suggestions.

Barbara Peever Gardner, R.N., is behind every sentence in this text as the rhetorical consultant and critical reader. Her contributions to readability and style are incalculable.

The host of persons that make up the publisher's staff cannot all be thanked individually for their efforts in the making of this book. Special mention, however, must be made of Lorraine Battista, who designed the book. Former editor Richard Lampert suggested some of the additions to this edition, while our new editor, Robert E. Lakemacher, has contributed innovations and publishing expertise that are gladly acknowledged by the authors.

We hope that the readers and instructors who use this book will continue their helpful practice of making suggestions, which are ever welcome.

WESTON D. GARDNER

WILLIAM A. OSBURN

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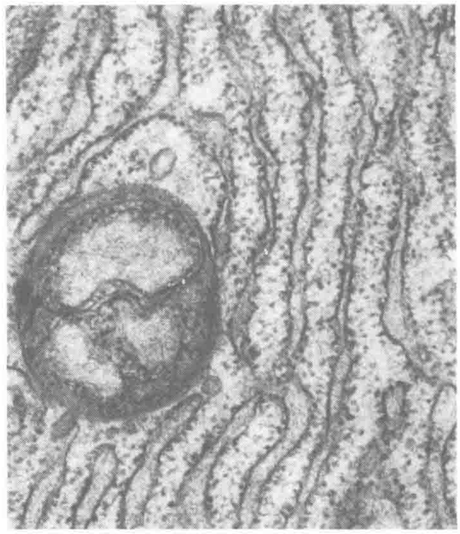
CHAPTER NINE

THE RESPIRATORY SYSTEM

CHAPTER TEN

CHAPTER ONE



INTRODUCTION

Objectives of this Chapter

In this chapter you will learn what anatomy is and the fields into which it is subdivided for study. You will come to understand how living matter is organized into cells, tissues, and organs. You will become familiar with the language of anatomy and learn how to use its terms. When you have completed this chapter you will understand how the human body develops from its simplest beginnings. You will be ready to embark upon the study of the systems that make up the human body.

Anatomy Defined

Anatomy is the study of the structure of living things. This definition includes the structure of the myriads of viruses and microorganisms, the simplest and most complex plants, and all the phylogenetic ranks of animal life which precede man in the science of biology. Human anatomy, with which this book is concerned, is the study of the structure of the living human body. Since structure is the framework that makes function possible, knowledge of human anatomy provides the basis upon which an understanding of function depends.

Approaches to Anatomy

Because human anatomy has been one of the oldest objects of man's curiosity it has developed into one of the most extensive bodies of knowledge. There are several ways to approach the facts of human structure which have been accumulated for centuries and have been refined or added to by modern developments in tools and techniques.

One approach to human anatomy is to realize that the human body is composed of cells, which combine to form tissues, which in turn combine in a variety of ways to form specific organs. Similar organs or even different ones, which unite either in location or in function to perform specific roles for the body as a whole, form organ systems. The human body may be studied by learning about one system at a time in its entirety, no matter into what portions of the body it may extend. Although parts of a particular system may come into relation with another, the major focus is upon the system being studied. This approach to the human body is known as *systematic anatomy*. This book is based largely upon such a systematic approach.

Another approach to human anatomy is found when the human body is looked upon externally. Systems are not seen, but the body appears to be made up of characteristic parts, such as the head, neck, trunk, and limb. One of these regions may be studied at a time in its entirety, taking notice of the appearance of structures of any systems which may be present. Attention is paid to the relationship of one component to another and its depth or extent. This approach is termed *regional anatomy*. From time to time in this book regional information will be presented, as in Chapter Eight.

Special Fields of Anatomical Study

It has become customary to divide the extensive subject matter of anatomy into special categories according to the concepts contained or the methods of study.

Gross anatomy is concerned with the structure of the human body which may be observed by the unaided eye. It is historically much the oldest field of anatomy, for its findings are largely derived from external observation or from dissection which did not have to await the development of special tools or techniques. This book is concerned mainly with gross anatomy.

Microscopic anatomy is devoted to the finer details of structure which can be recognized with the microscope. This body of knowledge is sometimes called *histology*, or the study of tissues. The field has progressed with refinements in microscopes and the techniques of preparing tissues for study. Although the light microscope is the classic tool of microscopic anatomy, new knowledge is constantly being acquired or old facts revamped by phase microscopes, ultraviolet and x-ray diffraction techniques, and the electron microscope. Investigation of the structure of tissues by a combination of microscopic and biochemical techniques has brought about the development of the new field of *histochemistry*. When the findings of microscopic anatomy are pertinent, they are mentioned in this book.

Developmental anatomy is the study of the human organism from its conception until its mature adult form is attained. One phase of the study of the development of the new individual up to the time of birth is a separate science, *embryology*. Developmental anatomy is concerned also with the growth of human structure throughout childhood and adolescence.

Topographic anatomy is limited to the conformation of the surface of the human body and includes the changes in form created by the action of muscles and changes in posture. Since these changes require life and motion, this study is often called *living anatomy*.

Neuroanatomy is a special study of the nervous system and sense organs of the body. It combines knowledge gained by gross and microscopic means. Today experimental approaches based upon electronics, physiology, and surgery are important in this field.

Radiological anatomy contributes knowledge which may be disclosed by x-ray methods. It reveals the pattern of structure in tissues or organs by means of shadows cast on a photographic film when x-rays are directed through the body.

THE ORGANIZATION OF LIVING MATTER

LIFE AND LIVING MATTER

One who begins the study of anatomy has already gained insight into the origins and characteristics of life during an earlier study of biology. The quality of life, which escapes easy definition, has been the climactic result of a number of processes in the physical world which began with the proper combination of elements under suitable environmental conditions in past eons of time. Compounds resulting from the combination of essential elements were forged into ever more complex molecules under the influence of catalysts and enzymes. The process continued with the formation of macromolecular complexes. Many similar complexes may be synthesized in modern biochemical and biophysical laboratories, but the products do not have the qualities associated with living matter or protoplasm. Protoplasm is differentiated from non-living combinations of similar chemical complexes by its possession of characteristics considered to be the *attributes of life*. The attributes of living matter are as follows:

1. Organization into units of specific size and shape.
2. Ability to enter into chemical activities of a constantly changing nature, resulting in the building or maintenance of protoplasm and the transformation of energy.
3. Movement.
4. Irritability, or the response to stimuli from the external environment.

5. Growth through an increase in the size and number of its structural units.

6. Ability to reproduce.

7. Adaptation to changes within the external environment.

CELLS

Protoplasm has been defined as the living substance of which an organism is composed. At low levels of magnification protoplasm appears to be structureless, that is, an amorphous, viscous mass. This mass, however, is organized into minute bits of the living substance called *cells.* Cells are the units of structure of the living body. The pioneer of microscopy, van Leeuwenhoek, saw cellular forms with his crude lenses. Hooke described them in the plant structure of cork. Schleiden and Schwann enunciated the cell theory which stated that cellular units were independent organisms which gathered together in complex ways to form plants and animals. Later came the dictum that all cells originate from pre-existing cells by division of their central nuclei. This law, *omnia cellula e cellula,* put to rest previous theories of the origin of life, such as spontaneous generation. The later work of Virchow, which elaborated the theory that disease occurs by alterations in normal cells, established the basis for medicine as we know it today.

There are millions of cellular units in the human body. Each cell possesses the attributes of life and manifests the form and structure which is characteristic of the function it performs in the body.

Cell Structure in General

With the development of staining methods to reveal cell structure, light microscopy showed that a cell is surrounded by an envelope or membrane. A central structure, the *nucleus,* is imbedded in a viscous mass of protoplasm that contains other structures, living and nonliving. Such a view of the cell was held until the 1950s. We know that strides in acquiring knowledge are greater following the development of new tools for research. Among several new techniques for cell observation was the electron microscope. This instrument has taken human vision beyond the limits of the light microscope. For instance, light microscopy can disclose structures measured in *microns* (thousandths of a millimeter), but the electron microscope reveals forms measured in *angstroms* (ten-thousandths of a micron). Therefore, the knowledge gained by the electron microscope is not a separate body of facts but an extension of the previous knowledge of the cell into a new frontier in which protoplasm is composed of molecules and macromolecular complexes, which in turn are recognized as the structures found by light microscopy.

In the brief account of cell structure that follows, those factors which are common to both light and electron microscopy are mentioned first. Accessory facts, related to newer knowledge of "ultrastructure" gained by biochemical or electron microscopic study, are presented in indented smaller type for those readers who desire this further information.

Overview of the Cell

The cell, without the aid of any staining, looks like a transparent, slightly refractile, jellylike sphere. When treated with chemicals in preparation for staining, the cell protoplasm undergoes precipitation of its electrolytes and coagulation of its proteins. After being stained with dyes, the cell appears to have a dense external membrane, an amorphous or delicately granular protoplasm, and a very dense, central body, the nucleus. The appearance of the protoplasm is deceptive. The granularity hides a host of submicroscopic structures and a lacy protoplasmic maze upon which, and within which, a number of complex proteins, carbohydrates, and fats intermix and interact. The myriad physical interfaces made possible by the lacy protoplasmic framework allow many metabolic reactions to proceed simultaneously, speeded by the catalytic force of enzymes. Such reactions are related to the nourishment of the cell, its energy reactions, or its special products.

The Chemical Basis of Protoplasm

The complex chemical structure of the cell may be reduced to very simple substances of molecular nature. These combine to form larger aggregates or *macromolecules.* There are three basic kinds of macromolecules in the cell: proteins, nucleic acids, and polysaccharides. It is important to understand these before going on to further study of the cell.

Proteins are made available to the cells by

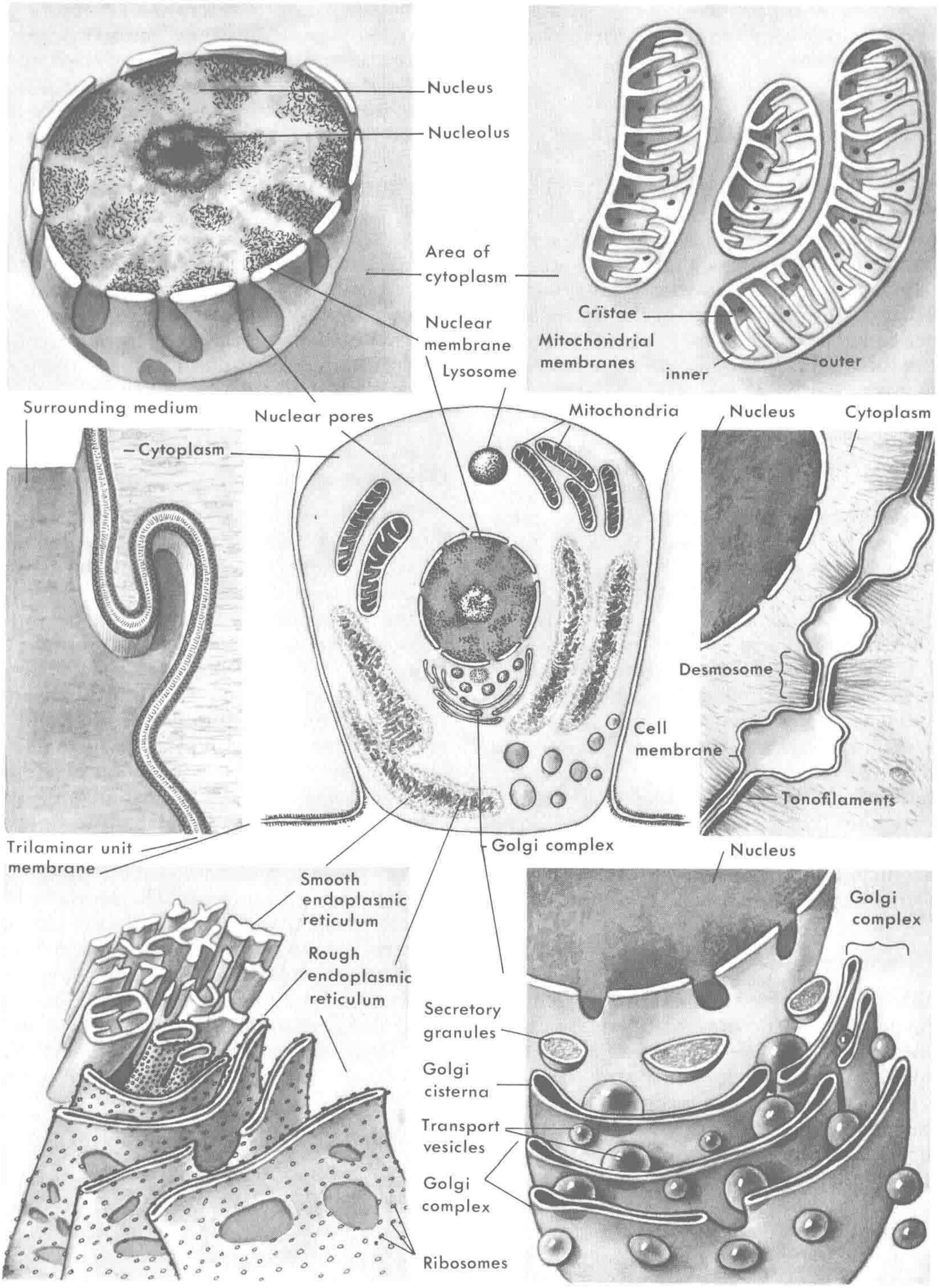

Nucleus
Nucleolus
Area of
cytoplasm
Nuclear
membrane
Lysosome
Crïstae
Mitochondrial
membranes
inner
outer
Surrounding medium
Nuclear pores
Mitochondria
Nucleus
Cytoplasm
Cytoplasm
Desmosome
Cell
membrane
Tonofilaments
Trilaminar unit
membrane
Golgi complex
Nucleus
Smooth
endoplasmic
reticulum
Golgi
complex
Rough
endoplasmic
reticulum
Secretory
granules
Golgi
cisterna
Transport
vesicles
Golgi
complex
Ribosomes

Figure 1–1

the digestion and absorption of foods and their transport into the tissues of the body. Proteins must be reduced to their simplest form, molecules of *amino acids*, before they can be used by the cell. These simple molecules are building blocks, or *monomers*, for cell activity. Cells use energy to chemically combine amino acids into macromolecular chains called *peptides*. These chains lengthen to form *polypeptides* by the process of *polymerization*. Many living structures of cells and tissues are formed by these macromolecules or *polymers*.

Nucleic acids are more complex macromolecules in which amino acids, sugars, and phosphates are combined. Nucleic acids have been shown to be of great importance in the synthesis of proteins, which form many parts of cells and tissues. Nucleic acids are also responsible for the storage and transfer of genetic information about an individual and his cells during reproduction and development (genetic coding). There are two types of nucleic acids. For simplicity, they are referred to as DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

The *polysaccharides* are macromolecules in which many simple sugars are polymerized to produce more complex substances. These substances will be mentioned as they participate in the structure of cells and tissues.

The cell is made up principally of water. In watery solution are many electrolyte ions, which are of great import to the life and integrity of the cell. Sodium, potassium, magnesium, calcium, and iron may be singled out, as well as the chloride, phosphate, and carbonate ions.

Cell Membrane

At the periphery of the cell, the protoplasm may be thickened to form a limiting membrane.

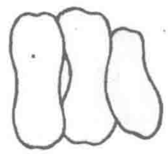


Figure 1–2

This may be punctured by microscopic manipulation to collapse the cell and to permit less viscous portions of the protoplasm to escape. In other cells the surface protoplasm may act as a membrane, rather than forming a definite boundary. In either case the cell is given form, its contents limited, and the diffusion of substances into and out of the cell permitted.

The cell membrane, also called the *plasmalemma*, usually consists of three layers forming a trilaminar boundary membrane at the surface of the cell. This *unit membrane* is

Figure 1–3