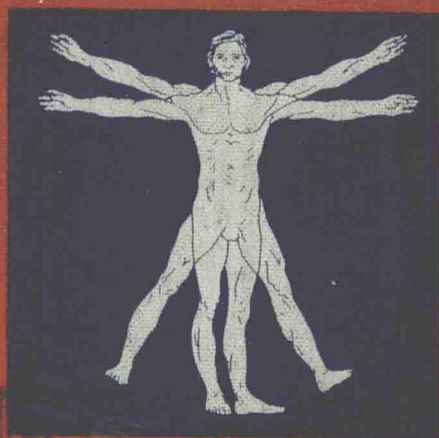


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# ANATOMY OF THE HUMAN BODY



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

# CONTENTS

## CHAPTER ONE

INTRODUCTION .....	1
The Organization of Living Matter .....	2
Life and Living Matter .....	2
Cells .....	3
Tissues .....	12
The Fundamental Tissues .....	14
Epithelium .....	14
Connective Tissue .....	18
Fluid Connective Tissue .....	18
Muscle Tissue .....	18
Nerve Tissue .....	19
Organs and Systems of the Body .....	19
Tissue Combinations .....	19
Organs .....	20
Organ Systems .....	21
The Language of Anatomy .....	21
The Anatomical Position .....	22
Planes of the Body .....	22
Terms of Position .....	22
Use of Terms .....	23
The Necessity for Classification .....	23
Development of the Human Body .....	24
Origins of the Human Body .....	24
Fertilization and Cleavage .....	24
Early Development of the Embryo .....	30
Later Changes in the Embryo .....	42
About Review Questions .....	42
Review Questions .....	43

## CHAPTER TWO

THE CONNECTIVE TISSUES .....	45
Connective Tissue in General .....	45
Functions of Connective Tissue .....	46
Basic Form of Connective Tissues .....	48

The Fibrous Connective Tissues .....	50
Loose, Irregularly Arranged Connective Tissue .....	50
Dense, Irregularly Arranged Connective Tissue .....	51
Regularly Arranged Connective Tissues .....	53
Modified Connective Tissues .....	56
Fat .....	56
Cartilage .....	57
Bone .....	60
Review Questions .....	65

## CHAPTER THREE

THE INTEGUMENTARY SYSTEM .....	67
The Skin .....	67
Epidermis .....	67
Dermis .....	68
Hairs .....	69
Glands of the Skin .....	70
Nails .....	71
Functions of the Skin .....	71
The Mammary Gland .....	72
External Appearance .....	72
Structure .....	72
Review Questions .....	73

## CHAPTER FOUR

THE SKELETAL SYSTEM AND ITS JOINTS .....	74
The Skeletal System in General .....	74
Functions of the Skeletal System .....	75
Number of Bones .....	75
Skeletal System Classification .....	75
The Study of Bones .....	78
Joints in General .....	79
Classification of Joints .....	79
Structure of a Generalized Joint .....	82
Joint Movements .....	85
The Study of Joints .....	86
The Axial Skeleton and Its Joints .....	86
The Vertebral Column .....	86
General Features .....	86
The Vertebrae .....	88
The Skull .....	98
The Cranial Vault .....	98
Anterior Aspect of the Skull .....	99
Lateral Aspect of the Skull .....	101
Base of the Skull .....	102
Cranial Cavity .....	104
Thoracic Skeleton .....	105
Sternum .....	105
Ribs .....	106
Joints of the Thoracic Skeleton .....	108
The Thoracic Cage and Its Movements .....	109

Pectoral Girdle .....	110
Scapula .....	110
Clavicle .....	112
Relations of the Pectoral Girdle .....	113
Joints of the Pectoral Girdle .....	113
"Scapulothoracic Joint" .....	114
Living Anatomy of the Pectoral Girdle .....	114
Upper Limb .....	115
Humerus .....	115
Scapulohumeral Joint .....	117
Bones of the Forearm .....	121
Humeroulnar Joint .....	124
Humeroradial Joint .....	125
Radioulnar Joints .....	126
Wrist Bones .....	126
Bones of the Hand .....	130
Carpometacarpal Joints .....	131
Bones of the Fingers .....	131
Metacarpophalangeal Joints .....	132
Interphalangeal Joints .....	132
Pelvic Girdle, Hip Bones, and Pelvis .....	132
Pelvic Girdle .....	133
Hip Bone .....	133
Joints of the Pelvic Girdle .....	136
Sacroiliac Joint .....	136
Symphysis Pubis .....	137
Pelvis .....	137
Lower Limb .....	139
Femur .....	139
Hip Joint .....	142
Patella .....	144
Bones of the Leg .....	145
Knee Joint .....	148
Bones of the Foot .....	151
Talocrural (Ankle) Joint .....	154
Joints of the Foot .....	155
Review Questions .....	158

## CHAPTER FIVE

THE MUSCULAR SYSTEM .....	160
Muscles in General .....	160
Muscle Tissue and Muscle .....	160
Structure of Voluntary Muscles .....	162
The Muscle and Its Attachment .....	166
Nerve Supply of Muscle .....	168
Functional Mechanics of Muscle Action .....	170
The Study of Muscles .....	172
Muscles of the Human Body .....	172
Muscles That Move the Head and Neck .....	172
Muscles of Mastication .....	176
Muscles That Move the Vertebral Column .....	176
Muscles Providing Facial Expression .....	182



Muscles Acting Upon the Trunk .....	187
The Diaphragm: A Muscle Acting Within the Trunk .....	195
Muscles Closing the Pelvic Outlet .....	197
Muscles Moving and Positioning the Scapula .....	197
Muscles Moving the Arm at the Scapulohumeral Joint .....	199
Muscles Moving the Forearm at the Humeroulnar and Humeroradial Joints .....	205
Muscles Moving the Forearm at the Radioulnar Joints .....	206
Muscles Moving the Wrist and Hand As a Whole .....	209
Muscles Producing Finger Movements .....	210
Muscles Moving the Thumb .....	217
Muscles Producing Movements at the Hip Joint .....	223
Muscles Producing Movements at the Knee Joint .....	229
Muscles Producing Movements of the Ankle and Foot .....	235
Muscular System in Posture and Locomotion .....	237
The Muscles and Posture .....	237
The Muscles and Locomotion .....	246
A Note in Conclusion .....	248
Review Questions .....	248
CHAPTER SIX	
THE NERVOUS SYSTEM .....	250
The Nervous System in General .....	250
General Functions of the Nervous System .....	251
Development of the Nervous System .....	251
Organization of Nervous Tissue .....	255
Organization of the Nervous System .....	259
Central Nervous System .....	261
External Morphology of the Brain and Spinal Cord .....	261
External Environment of the Central Nervous System .....	272
Blood Supply of the Central Nervous System .....	276
Peripheral Nervous System .....	280
Spinal Nerves .....	280
Distribution of the Spinal Nerves .....	283
Distribution of the Thoracic Nerves .....	288
Lumbar Nerves and the Lumbosacral Plexus .....	290
Autonomic Nervous System .....	293
Cranial Nerves .....	297
Major Nervous Pathways .....	313
Sensory Pathways .....	313
Motor Pathways .....	318
The Eye .....	320
The Ear .....	324
Review Questions .....	330
CHAPTER SEVEN	
THE CIRCULATORY SYSTEM .....	332
Functions of the Circulatory System .....	332
Blood .....	333
Overview of the Cardiovascular System .....	334

Vessels of the Cardiovascular System .....	336
The Heart and Mediastinum .....	338
The Heart .....	339
The Cardiac Conduction System .....	345
Blood Supply of the Heart .....	347
The Cardiac Cycle and Paths of Circulation .....	349
The Arteries of the Body .....	350
The Great Arteries of the Mediastinum .....	351
Pulmonary Trunk and Pulmonary Arteries .....	351
The Aorta .....	351
The Great Conducting Arteries .....	352
Arteries of the Head and Neck .....	353
Subclavian Branches to the Head and Neck .....	353
The Carotid Arteries to the Head and Neck .....	354
Arteries of the Axilla and Upper Limb .....	358
Axillary Artery .....	358
Brachial Artery .....	359
Arteries of the Forearm .....	360
Arteries of the Wrist and Hand .....	361
Arterial Supply of the Thorax .....	362
Arteries to the Mediastinum .....	362
Blood Supply of the Thoracic Wall .....	363
Arterial Supply of the Abdomen .....	364
Blood Supply of the Abdominal Wall .....	364
Blood Supply of the Abdominal Organs .....	365
Arterial Supply of the Pelvis .....	370
Iliac Arteries .....	370
Internal Iliac Artery .....	370
External Iliac Artery .....	371
Arteries of the Lower Limb .....	372
Blood Supply to the Thigh .....	372
Blood Supply of the Knee Region .....	375
Blood Supply to the Leg and Foot .....	376
The Fetal Circulation .....	377
Connections to the Placenta and the Alimentary Shunt .....	377
Pulmonary By-Pass .....	378
Veins of the Human Body .....	380
General Plan of the Venous System .....	381
Veins of the Body Regions .....	381
Lymphatic System and Spleen .....	388
Lymph and Lymphatic Capillaries .....	388
Lymphatic Vessels and Lymph Nodes .....	389
Lymphatic Drainage Pathways .....	389
Nonnodal Lymphatic Tissue .....	392
Spleen .....	392
Review Questions .....	392

## CHAPTER EIGHT

STRUCTURE OF SELECTED BODY REGIONS .....	394
Review Questions .....	409

CHAPTER NINE

THE RESPIRATORY SYSTEM .....	411
The Upper Respiratory System .....	411
External Nose .....	411
Nasal Cavity .....	413
The Paranasal Sinuses .....	414
Pharynx and Nasopharynx .....	417
Parts of the Respiratory System in the Neck .....	418
The Lower Respiratory System .....	423
The Trachea .....	423
The Tracheobronchial System .....	424
The Lungs .....	428
Mechanics of Normal Breathing .....	436
Review Questions .....	437

CHAPTER TEN

THE DIGESTIVE SYSTEM .....	438
Functions of the Digestive System .....	438
Development of the Digestive System .....	439
Reception of Food and Preparation for Swallowing .....	439
Structures for Testing of Food .....	439
Structures for Mastication .....	442
Organs of Salivary Secretion .....	443
Structures Related to Swallowing .....	444
Oropharynx .....	445
Laryngopharynx .....	446
Muscles of the Pharynx .....	446
Pharyngeal Component of Swallowing .....	447
Esophageal Component of Swallowing .....	448
Parts and Disposition of the Gastrointestinal Tract .....	450
Organs of the Gastrointestinal Tract .....	450
Disposition of Abdominal Organs .....	451
Peritoneum .....	452
Organs Related to Digestion .....	452
Stomach .....	452
Duodenum .....	456
Organs Related to Absorption .....	458
Jejunum and Ileum .....	458
Large Intestine .....	461
Organs Related to Evacuation .....	465
Rectum .....	465
Anal Canal and Anus .....	465
Accessory Digestive Organs .....	466
The Liver .....	466
The Pancreas .....	470
The Peritoneum .....	470
Review Questions .....	472

## CHAPTER ELEVEN

THE URINARY SYSTEM .....	475
Urinary System Overview .....	475
The Kidneys .....	476
Ureters .....	481
Urinary Bladder .....	482
Structures Closing the Pelvic Outlet .....	484
Pelvic Diaphragm .....	484
Perineum .....	485
Review Questions .....	489

## CHAPTER TWELVE

THE REPRODUCTIVE SYSTEM .....	490
Male Reproductive System .....	490
Female Reproductive System .....	496
Review Questions .....	504

## CHAPTER THIRTEEN

THE ENDOCRINE SYSTEM .....	505
Types of Endocrine Glands .....	505
Hypophysis .....	506
Anterior Lobe (Pars Distalis) .....	506
Intermediate Part (Pars Intermedia) .....	507
Tuberal Part (Pars Tuberalis) .....	507
Posterior Lobe (Neurohypophysis) .....	507
Clinical Aspects of Pituitary Hormones .....	508
Thyroid Gland .....	509
Parathyroid Glands .....	510
Adrenal Glands .....	512
The Pancreas .....	513
Ovary .....	515
Testicle .....	516
Debated Endocrine Organs .....	517
Review Questions .....	517

LEARNING FLOW CHART .....	519
---------------------------	-----

INDEX .....	541
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# 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 con-

formation 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 mil-

limeter), 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



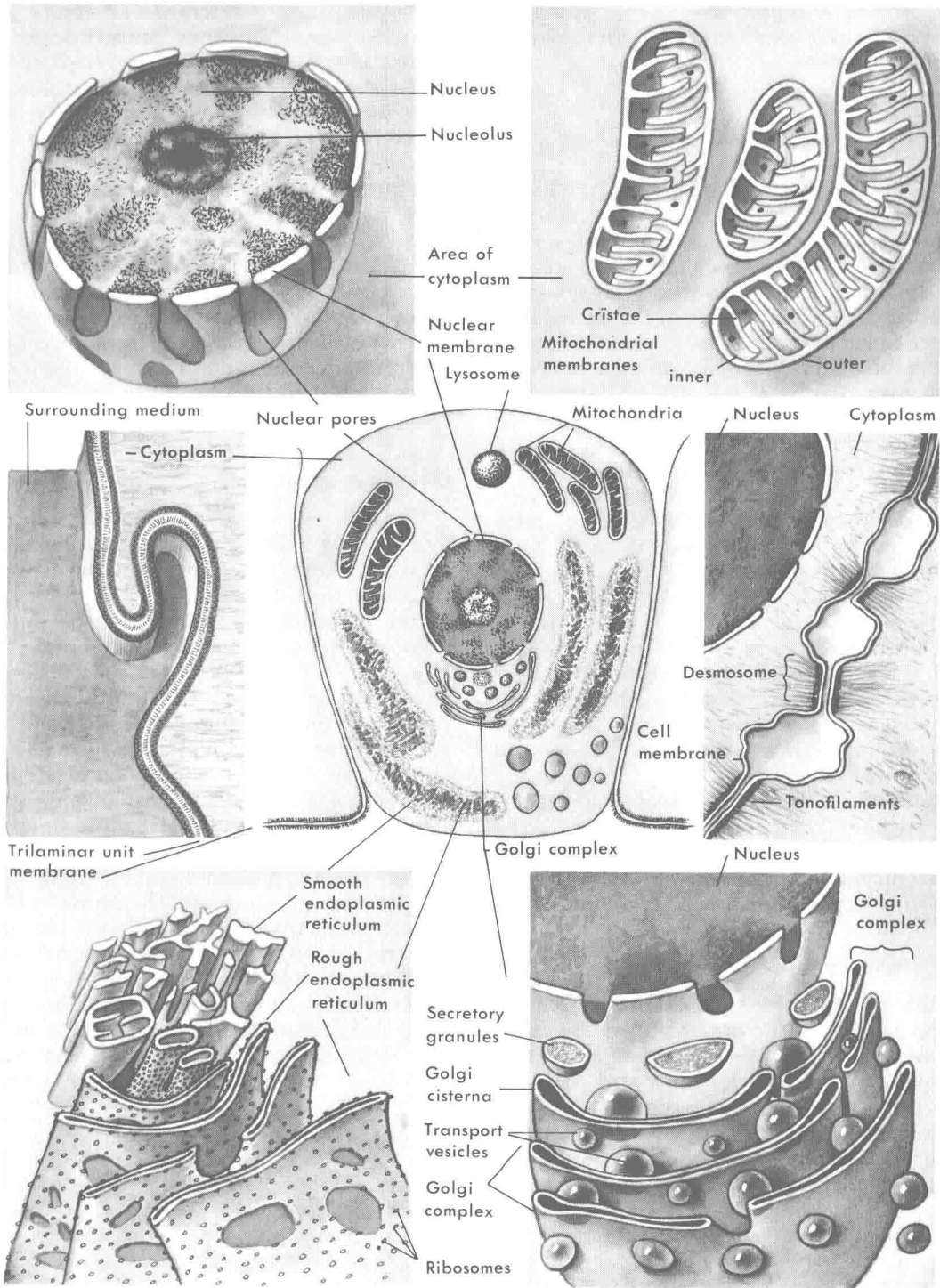


Figure 1-1



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.

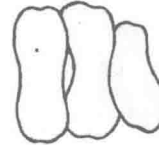


Figure 1-2

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

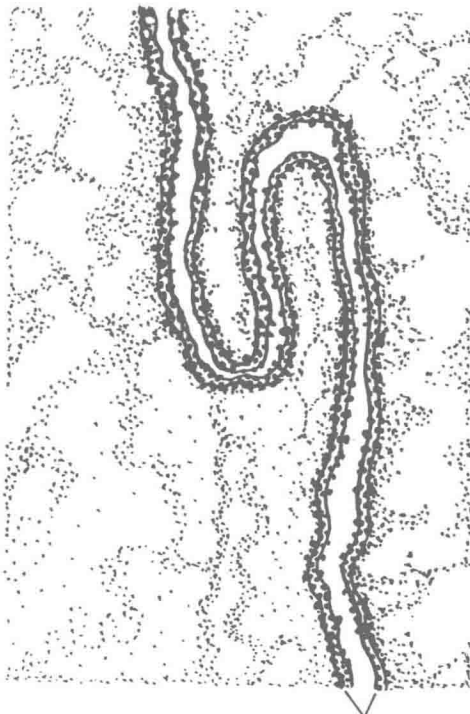


Figure 1-3



Trilaminar unit membrane