

# HISTOLOGY

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TO MY  
FATHER, MOTHER, WIFE



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## Preface to the Second Edition

The advances in Histology over the past few years have been more numerous and significant than those of any similar period of its maturity. The compilation of a second edition has permitted an account of many of these recent advances to be included. Moreover, it has permitted a more adequate treatment of certain subjects that seem to require it. In making changes every effort has been directed toward retaining the general approach to the subject that characterized the first edition. The plan of the book is unchanged. The major alterations and additions will now be outlined briefly.

The order of two early chapters was reversed to provide better sequence. More details have been given about some of the newer histologic methods. In particular, since many electron micrographs have been used as illustrations, the section dealing with the electron microscope has been expanded. A table, designed to help the student in learning how to estimate the size of objects seen under different magnifications, has also been included. Another important artefact has been illustrated.

The chapter on the Cell has been almost completely rewritten because of recent advances. It was considered essential to give a fuller account of the development of knowledge about the types of nucleoproteins (DNA and RNA) in cells and the histologic methods employed for their demonstration. It was also considered necessary to describe and illustrate the structure of chromosomes in more detail, so that the difference in the appearance of the sex chromatin of the interphase nuclei of somatic cells of males and females, discovered by Barr and his associates, could be illustrated and explained properly. I am grateful to Dr. M. L. Barr for help in preparing this section and for information about the use of the skin biopsy for determining the chromosomal sex of pseudo-

hermaphrodites and true hermaphrodites. In a more exhaustive consideration of nuclei the effects of colchicine on mitosis, the question of the constancy of their DNA content, and the mechanism of polyploidy are all discussed. The section dealing with mitochondria was expanded in accordance with new knowledge about their function and structure. I am grateful to Dr. G. E. Palade for providing electron micrographs to illustrate their fine structure. The golgi apparatus was discussed at greater length. The RNA of the cytoplasm required detailed consideration. In response to the carefully considered suggestion of Dr. C. P. Leblond—to whom I am indebted for many valuable suggestions—it was decided to use *ergastoplasm* as a general term for this material. Dr. G. E. Palade and Dr. K. R. Porter each provided a full-page electron micrograph illustrating endoplasmic reticulum, and each read the manuscript of this chapter while it was in preparation. I shall always appreciate their kindness. The relationship of ergastoplasm, endoplasmic reticulum and the submicroscopic particulates obtained by differential centrifugation required discussion, as did the possible relations of the ergastoplasm to the maintenance of the differentiated state, cell growth and cancer.

The chapter on Intercellular Substances now includes a description of collagenic fibrils and protofibrils, and of elastic fibers, as revealed by the electron microscope. I am grateful to Drs. Jerome Gross and F. O. Schmitt for providing four electron micrographs and helpful comment. A section dealing with the periodic-acid-Schiff reaction was also included as a prelude to a discussion of basement membranes and reticulum.

In connection with the cells of blood, a discussion of the possible functions of lymphocytes and of the relation of eosinophiles to allergic phenomena has been added.



The chapter dealing with Ordinary Connective Tissue has been expanded to include a discussion of recent work on the formation of fibers, and the development, the structure and the repair of tendons. Tendon sheaths have also received consideration. Many new illustrations have been added to the chapter on Bone. Resorption has been considered in more detail, and recent findings about osteoclasts have been described. The growth of a bone as a whole has been considered, and repair and transplantation have been treated more fully.

New illustrations have been added to the chapters on Hemopoietic Tissues. Knisely's concept of the splenic circulation has been illustrated.

Drs. H. S. Bennett and K. R. Porter kindly supplied two electron micrographs illustrating the fine structure of striated muscle. An account of the phenomenon of muscular contraction and another of the regeneration of striated muscle have been added. Further information about the innervation of striated muscle has also been included.

The chapter on Nervous Tissue in the first edition was not judged to be adequate; hence, it has been almost completely rewritten and expanded. Every effort has been made to keep the information presented within the bounds of comprehension of a student who has not yet studied neuroanatomy. I am most grateful to Dr. M. L. Barr for reading this chapter, for his many helpful suggestions and for providing many illustrations.

A new section has been written on the impulse-conducting system of the heart. Dr. J. W. A. Duckworth has been of the greatest help in its preparation; he also provided new illustrations for it. A section on the structure of lymphatics has been added. The biologic significance of fingerprints has received comment. Hard and soft keratin has been discussed and illustrated. The illustrations of hair follicles have been changed to show the distribution of the two types of keratin. The section on

the liver has been rewritten, and I am grateful to Dr. Hans Elias for permission to use two of his illustrations. Portal and classic lobules have been discussed in some detail. New work relating to the structure and the growth of lung alveoli has been described. The account of the kidney has been almost completely rewritten and expanded. I am most grateful to Dr. and Mrs. W. S. Hartroft for help in preparing this section and for helping with illustrations. Included in the latter is a color plate of a P.A.S. preparation of human kidney. The problem of the origin of the different anterior lobe hormones from different cells has also been considered. The hypophysioportal circulation has been described, and I am grateful to Dr. J. D. Green for permitting us to copy his illustration of it. Neurosecretion and the formation of posterior lobe hormones in hypothalamic nuclei have both been described, and I wish to thank both Dr. Ernst Scharrer and Dr. S. L. Palay for helpful advice. Dr. David Bodian kindly gave permission to reproduce his drawing of the pars nervosa of the opossum. The section dealing with the adrenal cortex has been largely rewritten, and the relation between cortical secretion and stress phenomena has been considered.

A few illustrations used in the first edition have been withdrawn, and about 144 have been added; sometimes these have been combined so that this edition contains only 73 more figures than the first. Among these are over 30 drawings—many full-page and 3 with color—by Louise Gordon, whose exquisite work reflects her interest. About 70 photomicrographs, mostly by Harry Whittaker, are included. To him I am most grateful. Dr. S. H. Bensley has always been ready to read new manuscript and give helpful advice. Dr. C. G. Smith aided me on several occasions. Miss Mary McConnell has again cheerfully and ably performed all the secretarial work. My publishers have always shown me every possible consideration.

ARTHUR W. HAM



# Preface to the First Edition

It is customary for the author, in his preface, to give reasons for having written that book. Psychiatrists are usually more cautious about this matter than most authors, tending to qualify their explanations with phrases such as "My conscious motivations was . . ." Probably the reasons advanced in many prefaces are not the author's real ones but only their rationalizations of ill-defined urges carried over from their youth. On thinking in this vein I suppose that my desire to write a book and, in particular, one that would be easy for students to understand, was born while I was a medical student as a result of having to use so many books that were difficult to understand. Direction was given to this impetus a few years ago by collaborating with Dr. M. D. Salter, a psychologist, in studying some of the common learning problems of students and in writing *Doctor in the Making*. These experiences suggested that the most obvious way to make a student's book understandable would be to take into account the common learning problems that students experience in the subject with which it deals. This has been done in this book which, therefore, deals to some extent with the problems of learning and remembering histology as well as with the subject-matter of histology itself.

The purpose of some of the measures adopted to facilitate the reader's understanding histology will be obvious on a casual glance; for example, the use of considerable space and many illustrations to help the student with the problems of three-dimensional visualization (Chap. 3). These problems are of peculiar importance in the study of histology, and if they are not understood they can be a major obstacle to a student's progress. Illustrating the common artifacts (Figs. 16-19), near the beginning of the book, is another measure, the purpose of which will be obvious to any

readers who have taught histology, for they will know that artifacts, until they are explained, cause endless confusion. The order of the book, with its contents divided into four sections, and with each section broken into main divisions and subdivisions, obviously is adapted to permitting the student to organize and classify its subject matter in his mind with a minimum of disorder.

On the other hand, some of the measures employed to make histology more readily understood and, in particular, more easily remembered are not so obvious as the foregoing one and perhaps should be explained here lest the informed reader who did not understand their purpose might think, on reading certain paragraphs, that unnecessary material was included.

First, it was kept in mind in writing every chapter that a student commonly studies histology before he has advanced very far with the study of gross anatomy and before he has begun the study of neuroanatomy, physiology, biochemistry or pathology. This requires that a textbook of histology—if it is to present the subject in its proper perspective and be easily understood by the student reader—must contain much explanatory material that might seem superfluous to the *informed* reader.

Secondly, experience in teaching pathology years ago made me realize that students readily forget a great deal of what they are assumed to have learned in the usual course in histology. Psychologists tell us that whether or not a thing is remembered depends largely on the depth of the impression that it makes on the mind and on how firmly it is tied into the mind with the bonds of association. The purpose, then for correlating the subject matter of histology with that of as many other subjects as possible, and even with the practice of medicine itself in this book, is to put the



facts of histology in such a perspective that they will make deeper impressions on the mind of the reader and at the same time provide the associations necessary for these impressions to be firmly tied into the mind for long-term retention.

In addition to the measures taken to facilitate the reader's understanding and remembering histology, there are other features of this book which perhaps should be mentioned here.

Since this is a new book it was comparatively easy to make an attempt to proportion the space allotted to the different aspects of histology in relation to the trends of the times. According to life-insurance statistics, degenerative diseases of the heart and arteries now account for more than half of the deaths for which claims are made. Accordingly, a considerable amount of space is allotted to the histology of the tissue ingredients and structures in the body in which degenerative phenomena occur. Thus a full chapter is devoted to intercellular substances and in this an account of the evolution of knowledge about hyaluronidase (spreading factor) is included. The problems that arise from the intercellular substances having to serve the dual role of providing support and of acting as a medium through which the nutrition of cells is achieved are emphasized. A discussion of this matter leads naturally to a full consideration of tissue fluid, and a full chapter is allotted to this subject and to the various mechanisms that account for edema (Figs. 59-64). The peculiar problems involved in the nutrition of arterial walls, as a possible background for the understanding of the prevalence of arteriosclerosis, is commented on at length. The mechanism of thrombosis is also explained; indeed, a full chapter is devoted to platelets and fibrin.

A background for the understanding of cancer, the second greatest cause of death in recent years, is laid in the chapter dealing with the cell. Here growth and differentiation are dealt with at some length, and the nature of cancer itself receives comment.

Some of the newer work on nucleoproteins is also included. The morphologic differences between somatic cells of males and females, very recently discovered by Barr and Bertram, are described and illustrated (Fig. 358). Although the chapter dealing with bone includes much original work and is written with many clinical applications in mind, it is longer than usual, chiefly because adequate space was taken to explain properly this topic which, of all those in histology, students commonly find to be the most difficult. Although it would be premature to use the new terminology recently suggested by a committee of the American Association of Clinical Pathologists and endorsed by the International Society of Hematologists, in the text dealing with the blood and hemopoietic tissues, the new names for blood cells and their antecedents are listed beside their synonyms used in the text at the end of the section dealing with hemopoietic tissues so as to be available as the new terminology becomes more widely used.

The modern trend in teaching anatomy accounts for the inclusion of no more than a general description of the microscopic structure of the tissues comprising the central nervous system; the details of this structure are given in the modern course in neuro-anatomy and hence in the textbooks that deal with this subject. This is as it should be, for microscopic anatomy in this field is scarcely intelligible until the gross anatomy of the brain and the cord is also studied. However, the tissues of the peripheral nervous system, including nerve endings and the organs of special sense, still seem to be the property of the general histologist; hence, these matters are dealt with at some length in this book. An introductory discussion of the autonomic nervous system is also included in order that students may have some appreciation of the type of innervation with which the smooth muscle and the glands of the body are supplied. So far as may be accomplished in histology, an effort was made in this connection to lay



the groundwork for students developing a psychosomatic point of view.

In accord with the general theme of illustrating the practical applications of histology, the subject of burns and skin grafting commands considerable attention in the chapter on skin. Much original work, particularly with regard to the different capillary beds affected by burns of different depths, the repair of skin, and the methods by which skin grafts are vascularized, is included. Original work also influenced the account of the development of the lung and the concept of the nature of respiratory tissue that is presented. The new findings described by Trueta and his associates regarding the circulation of blood through the kidneys are presented in some detail. The fact that the various forms of arthritis constitute the greatest single cause of disability in the civilized world was thought to be sufficient justification for a full chapter on articulations.

The great advances made in endocrinology during the last two decades justify much more space being devoted to endocrine glands and the reproductive system than was necessary in the past. Moreover, in writing the chapter dealing with these systems the view was taken that in this field microscopic structure and hormone balances are so interrelated that they cannot be separated effectively; hence, the treatment given these chapters is histophysiologic in type and therefore somewhat extensive. Since diabetes in 1946 ranked ninth as a cause of death in the United States, it was thought only proper to devote a considerable amount of space to a discussion of the islets of Langerhans and their relation to diabetes and to the other endocrine glands concerned in this condition. This and other parts of the account on endocrine glands are

salted with personal experiences in this field of research.

Over ninety per cent of the illustrations are new or original and almost all of these were prepared specially for the purpose. Over one hundred and forty new drawings, the majority of which were made by Dorothy Chubb and Louise Gordon, are included, together with over four hundred new photographs, mostly photomicrographs. Particular attention was paid to labeling both the drawings and the photomicrographs clearly so that students would be able to use the book efficiently in the laboratory. Some illustrations were taken from eminently suitable material already in the literature, and I wish to acknowledge the kindness of those who granted permission for their use.

Enough has been said to suggest the manner in which this book may exhibit individuality. I should like to remind the reader that, since the time of Virchow, histology has been the chief basis in reality for our concepts of normal and disease processes. With modern medicine becoming more complex every day, this is a very impressive function for histology to perform, and its contemplation leads to the conclusion that present-day students should be learning more rather than less histology. It also suggests that although this book is primarily designed as a text for such general courses in histology as are given to students in medicine, biologic science and dentistry, it may be found useful also to those graduates of medicine who feel the need of increasing their background knowledge in one or in many fields in order to understand better some of the problems of the day.

ARTHUR W. HAM





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PART ONE

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