THIEME FLEXIBOOKS

Human Histology, Cytology and Microanatomy

by Helmut Leonhardt
Translated by D. P. Winstanley

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Preface to the 4th German Edition

This new edition of the histology pocketbook contains numerous alterations, some of them extensive. The need for these alterations arose partly from advances in certain fields such as immunology and endocrinology and partly from didactic reasons. The chapters mainly affected are those on cytology, connective and supporting tissues, blood and hemopoietic organs, endocrine glands, nerve tissue, nervous system and skin. Prof. Dr. W. Specht, Homburg (Saar), kindly undertook a thorough revision of large parts of the chapters on connective and supporting tissues and on blood and hemopoietic organs. I am indebted to several specialist colleagues and certain students for useful hints. These have been carefully considered and I am always ready to receive further comments. The list of references has been considerably expanded and subdivided into subjects. It now provides detailed guidance to the literature and is intended for those with special interests, in particular graduates or undergraduates working on theses. I am indebted to Dr. h. c. G. Hauff for making these extensive changes possible. Nevertheless, the text as a whole has been kept within its original length by concentrating on information essential for an understanding of the functional aspects of cytologic and histologic structures. Additional information has been printed in small type. In the sections devoted to special histology more attention has been paid to microanatomy, both in the text and the illustrations, and it seemed justifiable to expand the title of the book. Many illustrations have been replaced with improved ones taken without individual acknowledgement from my volume "Internal organs" of the pocketbook atlas. These illustrations were prepared by Herr G. Spitzer. Frau H. Zuther and Fräulein E. Östermann contributed to the production of the new electron micrographs and Frau A. Schaller assisted in the compilation of the index. I wish to thank them and also the staff of Georg Thieme Publishers.

Homburg (Saar), December 1973 HELMUT LEONHARDT

From the Preface to the 1st German Edition

A short textbook owes its shortness mainly to what is left out; there is no room for full discussion of problems or detailed presentation of evidence. Those who are interested will find exhaustive descriptions and references to the literature in the major textbooks of histology and cytology (see reference list at the end of this book). The text has been still further compressed by extracting as much material as possible from the chapters on special histology and dealing with it in the sections devoted to general histology; nerve tissue and the nervous system, for example, are described together. In order to understand the arrangement of the book it is important to read the introduction. Light microscopic and electron microscopic appearances are described in parallel under the appropriate headings. So far as possible each description begins with an account of what can be seen with the unaided eye and progresses step by step into the higher ranges of magnification.

In drafting the text I received help from many quarters. First of all I wish to thank Prof. Dr. Bargmann, whose encouragement and constructive criticism were of the greatest value. Most of the histologic and microscopic illustrations were drawn from photomicrographs belonging to the teaching material and collections of the Anatomical Institute, University of Kiel. Herr K.-H. Seeber was responsible for the majority of the illustrations. I am also indebted to Dr. med. h. c. G. Hauff who originally proposed that I should write this book, and to Georg Thieme Publishers for valuable assistance. In writing the book I drew on experience gained in working with medical students in lectures and courses, and with my son Matthias.

Kiel, June 1967. HELMUT LEONHARDT

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Introduction

The aim of this pocketbook is to build up knowledge step by step in the same way as a textbook. It is arranged in such a way that the reader starts from observation and method, each step marking the progress of an investigation which can be seen in perspective by consulting the table of contents.

Contents

I. Cytology. The first step is to grasp the degrees of magnification used in microscopic studies. Every finding must be put in its right place in a series of objects arranged in order of magnitude. To guide the reader in case of doubt, light microscopic findings are marked with **L** and electron microscopic findings (at magnifications up to one hundred times greater) with **E.** Erythrocytes (diameter 7.5 μm) can be used as size standards in sections, and cell nuclei (normally 4–10 μm) also serve as guides to the magnification. Next follows an account of the changes (artefacts) likely to be produced by the technical methods employed. Attention is then turned to the cell, which is studied in three stages:

1. The living cell in tissue culture.
2. The killed cell as seen under the light and electron microscopes.
3. Analysis of the vital phenomena of the cell.

II. General and Special Histology: Tissues and organs are discussed in logical sequence. The section on epithelium leads on to a description of the various kinds of glands, and the account of connective tissue is linked on one side with blood, hemopoiesis and lymphoid organs, and on the other with bone and cartilage. Unless otherwise stated, the illustrations are based on ordinary staining techniques.

Revision: Each section of the text has a heading. When revising the material, these headings should be used as questions to be answered.

The remarks on physiology and biochemistry are incomplete and are simply intended to give the beginner some preliminary concept of the functions of an organ or tissue when he is studying its histology; further information can be obtained from textbooks of physiology and biochemistry.

PART 1:

Cytology

Techniques and Magnifications Used in Microscopic Study

One of the main aims of the biological sciences is to trace back the enormous diversity of living matter to a limited number of laws or principles. In morphology this implies a search for structural units and principles. How far this search can be pursued depends largely on the techniques available.

The *naked eye* can distinguish certain structural elements by their shape, color and surface texture, and by inspection of the cut surface.

Examined in this way, it is obvious that organs are built up from different units. Aristotle developed a theory of this kind around 350 B. C., but the limited resolving power of the human eye precluded further progress.

The *microscope*, introduced in the early years of the 17th century, gives magnifications of several hundred diameters and shows a whole range of new structures. Our current ideas of the structure of biological objects are based mainly on light microscopic investigations carried out during the last hundred years. The discovery of the cell was the key to the understanding of the structure of living organisms.

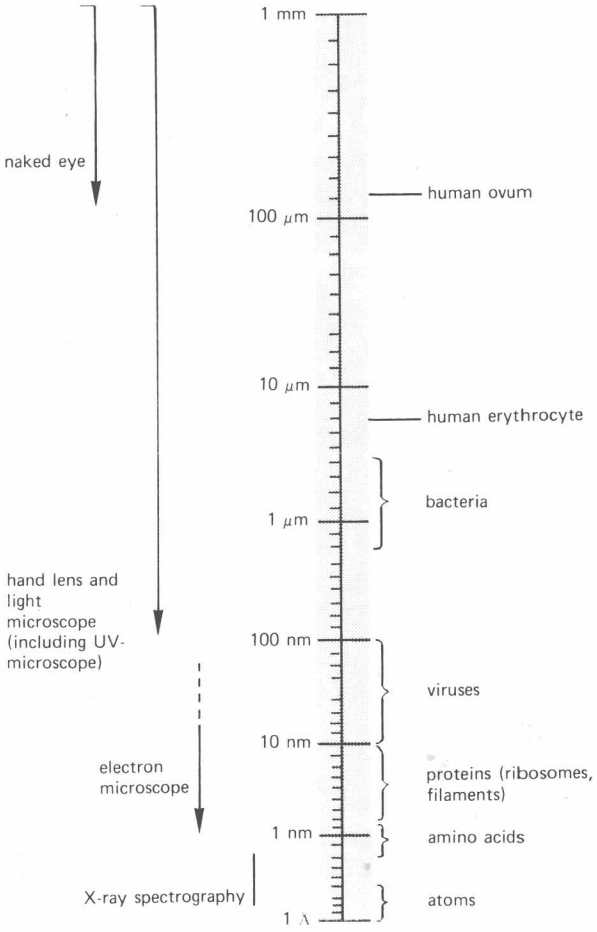
The development of *electron microscopy* during the past 20–25 years has revealed certain structures never seen before and has disclosed many new details in familiar objects. This has called for wide revision of our ideas of the structure of living matter.

Histologic teaching has to take into account the practical needs of future doctors, and it would be unreasonable to abandon the established orthodoxy of light microscopy. In any case, the only way to acquire an allround knowledge of the organization of living matter is to correlate the pictures obtained at all levels of magnification – hand lens, light microscope und electron microscope.

For proper understanding of histologic preparations it is essential to have some knowledge of microscopic and histologic techniques. The next few pages therefore contain a short account of the processes and problems involved in the production and examination of histologic preparations.

Dimensions

1 mm = 1,000 μm (micrometer), sometimes written μ (micron)
1 mm = 1,000,000 nm (nanometer), sometimes written mμ (millimicron)
1 mm = 10,000,000 Å (Ångström unit – now obsolescent)



Scale of microscopic and submicroscopic dimensions (from Bessis)

To convert measurements from one scale of magnification to another it is helpful to remember two equations:

10 Å or 1 nm (electron microscopic levels) = $^1/_{1000}$ μm
1 μm (light microscopic levels) = $^1/_{1000}$ mm

Limits of resolving power:

unaided eye ..... approximately 0.1 mm
light microscope ..... approximately 0.1 μm
electron microscope ..... approximately 1 nm = 10 Å

Examination with Naked Eye and Hand Lens

The only instrument needed is a simple *hand lens*. Major topographical relationships can be recognized. These are often difficult to make out under the microscope and inspection with a hand lens can be of great help. *Low power binocular microscopes* enable structures of this size to be dissected. The lower limit of optical resolution (the smallest separation at which two points can still be perceived as separate) is approximately *0.1 mm* for the naked eye. This means that structures such as intestinal villi, central veins of the liver lobules and gastric pits can just be seen.

Examination by Light Microscopy

The **light microscope** consits of a system of lenses by which the final magnification is achieved in two stages. The objective lens produces an enlarged inverted real image which is further enlarged by and viewed through the eyepiece or ocular (Fig. 1). The limit of optical resolution by light microscopy (UV-microscope) is around *0.1 μm*. Dark field microscopy enables still smaller objects to be seen.

Vital preparations. Certain thin objects such as the mesentery of a small animal, blood smears, etc., can be observed by transmitted light. For thicker objects it is necessary to illuminate the surface by incident light. Transmitted light can be employed in special ways which offer certain diagnostic advantages:

Ultraviolet light, emitted by a mercury lamp and passed through a filter to remove visible wave-lengths, excites fluorescence in many cell components and metabolic products. This *intrinsic fluorescence* must be distinguished from the fluorescence produced by staining with fluorescent dyes or fluorochromes: *vital fluorochrome staining (UV-microscopy)*.