FIFTH EDITION

Essentials of HISTOLOGY

GERRIT BEVELANDER

ESSENTIALS OF
HISTOLOGY

GERRIT BEVELANDER, A.B., M.A., Ph.D.
Professor of Histology, University of Texas, Dental Branch, Houston, Texas

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With 238 figures and 4 color plates

THE C. V. MOSBY COMPANY
Saint Louis 1965

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Library of Congress Catalog Card Number 65-11695

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PREFACE

As stated in the first edition, the purpose of *Essentials of Histology* is to present to the beginning student in a clear and concise manner the essential facts concerning tissues and organs.

Since the publication of the first edition, several remarkable advances have been made which have resulted in the clarification of structure and function of tissues, cells, and organs. This knowledge has been derived from a multidisciplinary effort following the development or refinement of new methodology in electron microscopy, histochemistry, cellular physiology, and other related disciplines. The net result of these combined efforts has greatly enhanced our understanding not only of the structural-functional relationships of the cell, but also of the interdependency and the role of specific cellular components in metabolic events at the molecular level.

The introductory remarks dealing with the cell have been amplified to include an illustration of the modern concept of the structure of the cell as observed with an electron microscope as well as a cell photographed at the maximum resolution of the light microscope. In addition, brief descriptions of some of the modern concepts of function as related to the various components of the cell, as well as material dealing with functional aspects of several organ systems, have also been included.

Some revision or amplification has been made in most of the chapters. A prominent feature of the present edition is the inclusion of approximately one hundred new illustrations. Fifteen of these are electron photomicrographs. The remainder are conventional light photomicrographs of tissues and organs the student is most likely to study in a beginning course in histology.

I wish to express my appreciation to the several teachers and colleagues who have offered suggestions designed to clarify certain passages in the text. To Dr. Hiroshi Nakahara for his contribution in the preparation of the new photomicrographs and to Professor Leon Kraintz for his aid and counsel relating to functional aspects of cells and organs, I am especially grateful.

Gerrit Bevelander
Houston, Texas

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ESSENTIALS OF HISTOLOGY

Chapter 1

INTRODUCTION

Histology is the science that deals with the detailed structure of animals and plants and in its broader aspects correlates structural features with function. Vital functional units are called cells. Not only do different kinds of cells exhibit variations in form and structural content, but the same cell may vary in these respects with changes in its physiological status. Our knowledge about cells and cell products has been obtained by a study of "fixed" or dead cells and by a variety of ingenious methods developed to study living cells. Each of these methods has advantages and disadvantages, but they are mutually complementary and we may conclude that all normal cells have certain attributes in common.

Cell structures and cell products are made visible by the use of certain dyes. The traditional stains are hematoxylin and eosin (H & E). The basic dyes, like hematoxylin, stain the chromatin of the nucleus (basophilia), whereas the acid dyes, such as eosin, tend to stain the cytoplasm (acidophilia, oxyphilia). Although many other dyes are used, most slides utilized in routine histologic and pathologic studies are hematoxylin and eosin preparations. These dyes have the great advantage of relative stability, universal use, and reproducible results.

THE CELL

Most cells are composed of a single nucleus embedded in cytoplasm (Fig. 1). The term *protoplasm* is used to designate the living substance of both the nucleus and cytoplasm. Protoplasm is a grayish viscous liquid (hydrosol) enclosed at all interfaces by a membrane (cell membrane). The cell membrane selectively regulates the interchange of materials between the cell and surrounding environment and upon death becomes completely permeable, or nonselective.

Nucleus

The nucleus, or *karyon*, usually appears as a spherical or ovoid body bounded by a nuclear membrane. The nucleus contains a fluid (nuclear sap) in which is found a dark-staining, eccentrically placed small sphere, the *nucleolus*, and in addition contains a fine lacy network upon which

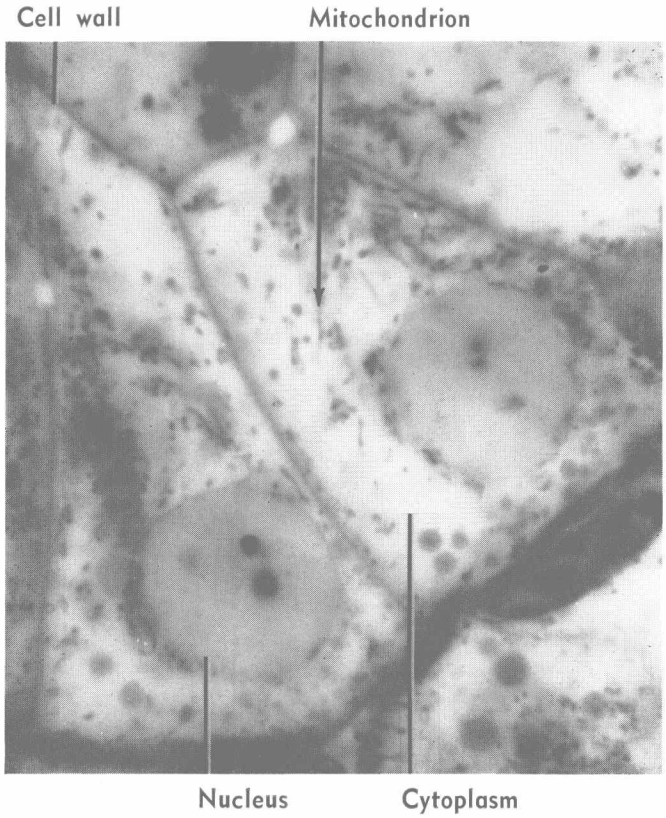

Fig. 1. Liver cells of turtle showing mitochondria and other cytoplasmic inclusions. (Iron hematoxylin, ×1,000).

dark-staining *chromatin granules* or flakes appear to be lodged. Whereas the nuclear sap is rarely stained, both the nucleolus and chromatin granules are strongly *basophilic* and stain a deep purple or blue with hematoxylin. With certain dyes, the two may be distinguished. Toluidine blue stains chromatin blue (orthochromasia), but the nucleolus, containing ribonucleic acid (RNA), stains purplish (metachromasia) with the same dye. Many nuclei exhibit two or three nucleoli. Nuclei are said to be *vesiculate* (bladderlike) when chromatin granules are finely dispersed (or dustlike) and *condensed* when chromatin granules are clumped into one or several dark-staining masses.

In some cells, such as white blood cells and megakaryocytes, the nuclei may be *lobed*, the lobes being connected by fine strands. In others, such as liver cells, osteoclasts, and skeletal muscle fibers, the cell may contain two, three, or more nuclei embedded in the same cytoplasmic mass (a condition sometimes referred to as a *syncytium*). In degenerating megakaryocytes and giant embryonic yolk cells the lobes may become completely separated *(karyorrhexis)*. In red blood cells the nucleus is extruded, and these enucleated cells cannot divide.

Cytoplasm

Cytoplasm, when observed in the living state, appears as a relatively transparent viscous *ground substance*. This ground substance is strongly acidophilic and stains with acid dyes like eosin or orange G. It contains numerous granules, filaments, and globules. These fall into two main groups known as *organoids* and *inclusions*. The organoids are believed to perpetuate themselves by autoduplication and to perform most of the metabolic functions of living systems. During cell division these particles are distributed between sister cells in what appears to be a systematic but semiquantitative manner. Included in this group are mitochondria, the Golgi apparatus, fibrils, centrioles, and the so-called chromophil substance (Fig. 2).

Mitochondria occur in all animal cells as rods, filaments, or granules. With the aid of phase microscopy they are usually demonstrable in living cells or may be made visible by exposing living cells to the dye Janus green B in the presence of oxygen. After special fixation they may be demonstrated with iron hematoxylin or acid fuchsin. In routine hematoxylin and eosin preparations they are destroyed.

The *Golgi apparatus* consists of a meshwork of lipid-containing fibrils that are usually supranuclear in position, that is, between the nucleus and the free surface of the cell. By the use of special fixatives, which may contain osmic acid or silver salts, the Golgi bodies appear black. Fat solvents may remove the lipid portions of these structures. Correlated with the secretory activities of certain cells is the occasional appearance of small vacuolated structures within the filaments known as vesicles (bladder). In addition to variations in the appearance of the Golgi bodies from cell to cell, cyclic variations occur in the same cell, as noted previously.

The *central body* (attraction sphere) also lies in the supranuclear position, sometimes producing a small indentation in the nucleus. It consists of a sphere of clear cytoplasm, the *centrosphere*, which contains one or two prominent granules known as *centrioles*. In many instances the centrosphere is surrounded by a group of delicate radial fibers called the *aster*. During cell division the centrioles separate and migrate to opposite sides of the nucleus during division of the nucleus. Some investigators believe that, in addition to being implicated in the process of cell division, the centrioles may also perform other physiological functions.

The *chromophil substance* appearing prominently in nerve cells, salivary gland cells, and acinar cells of the pancreas is strongly basophilic and metachromatic, suggesting the presence of RNA. Extraction of stainable material by the enzyme ribonuclease supports this contention. Changes in chromophil substances occur during cellular activity, and recent evidence indicates that RNA is implicated in protein synthesis.

Fibrils occur in many cells. They are especially prominent in nerve (neurofibrils) and muscle cells (myofibrils). In epithelial cells they are known as *tonofibrils* and do not pass from cell to cell, as previously supposed.